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Here's The Maintenance Man—

Who Earns a Lot More Credit Than He Gets

THE other day I picked up a shop house organ of the Hygrade Lamp Company of Salem, Mass., and got a whole lot of satisfaction from a little item about its maintenance department and the significance that is attached to the maintenance man's work in that plant. It read something like this:

Did you ever give a thought to the knowledge that a maintenance man must possess? Not only does he know how to do all kinds of mechanical and electrical work, such as operating a lathe, shaper, drill, milling machine and numerous other machine appliances, but he also knows the strong points and weak spots in electrical machines, something of the heat treating of various kinds of metal; installing electrical wiring and equipment one day, then working on something made of brass, something of asbestos, fiber, wood or any of the numerous kinds of stock carried in the tool crib.

Do you know what happens when a motor or the machine it drives breaks down either through negligence, long use, or abuse? I'll tell you. Immediately a "Rush!" order is sent through to the Maintenance Department and, like the good doctor who answers all emergency calls of the sick, the "maintenance man" is on the job to get that machine going again as soon as possible, so as not to interfere with production; for without production we soon wouldn't need any machines or anything else. So you see he is always interested in the upkeep of all departments. Although he does not actually make our company's product, he does take pride in the fact that he at least makes it possible for others to do so.

Now all you foremen look at your departments and see if you could run them as efficiently as now without the assistance of the maintenance men. I hardly think you could, do you?

You bet you couldn't! I've spent my happiest times with these fellows who are ready to work their finger tips off to help department heads out of a bad predicament, and all they look for as a reward is the satisfaction of making a nasty trouble job look easy and save the boss from worry over what he thought at first was going to cost a nice sum of money or a delay in shipping a rush order that would bring a lot of kicks and call for some unexplainable explaining upstairs.

After all, it's the maintenance man who keeps the wheels a-turning and he earns a lot more credit than he gets.

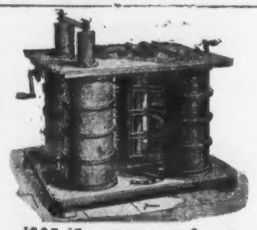
Practical Pete

The Transformer

From 1831 to the Present Date

FARADAY made the original transformer in 1831 by winding a primary and a secondary coil on an iron ring. Varley improved this by employing iron wires which led to our present laminated cores. Rhumkorff in 1842 invented his coil, which differed from Stanley's in that it was wound around a straight iron core with an open magnetic circuit. The open magnetic circuit was not entirely discarded until about 1891. The early transformer of Elihu Thomson, 1879 and of Gaulard and Gibbs, 1883, had open cores. The Gaulard and Gibbs system, which had been tried out in Europe, was first brought to this country in 1884 by George Westinghouse. In this and other systems of that date, the transformers were in series on the primary side. Although Rankin Kennedy had suggested parallel connection in 1883, it remained for Stanley (under Westinghouse's patronage) in 1886 to put his idea into practical use. From his plan our present systems have grown. Probably the first shell-type transformer was that of Zipernowski and Deri, made in 1885. Dobrowolsky built a three-phase design in 1891. The use of oil in transformers started about 1885 and attempts to secure better iron in 1890 but it was not until 1903 that silicon steel was adopted for cores.

1831 - FARADAY

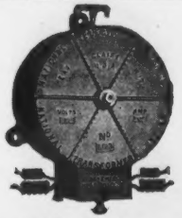


1883 - GAULARD AND GIBBS

1885 - ZIPERNOWSKI AND DERI

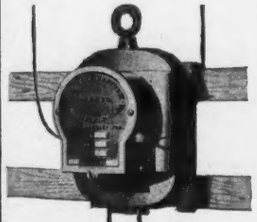
1888 - SLATTERY (Ft. Wayne)

1890 - SWINBURNE'S HEDGEHOG



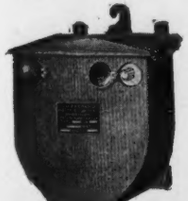
1890 - NATIONAL

1890 - WESTINGHOUSE



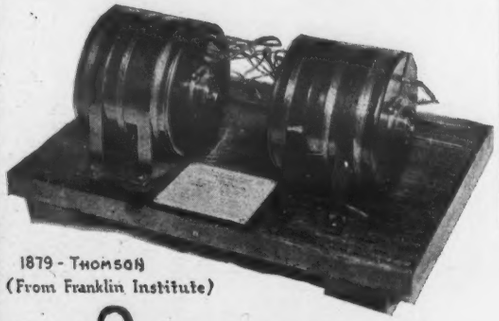
1891 - STANLEY

1892 - GENERAL ELECTRIC

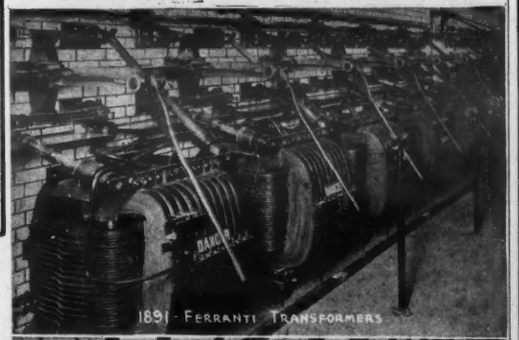


1894 - PACKARD

1894 - WAGNER

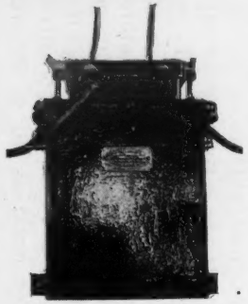


1879 - THOMSON
(From Franklin Institute)



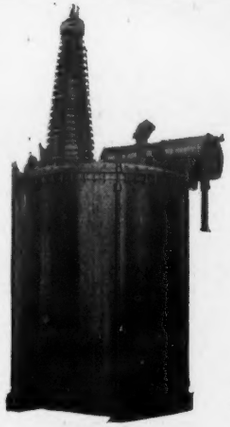
1891 - FERRANTI TRANSFORMERS

1890 - WESTINGHOUSE
(From Smithsonian Institution)



1887 - THOMSON-HOUSTON

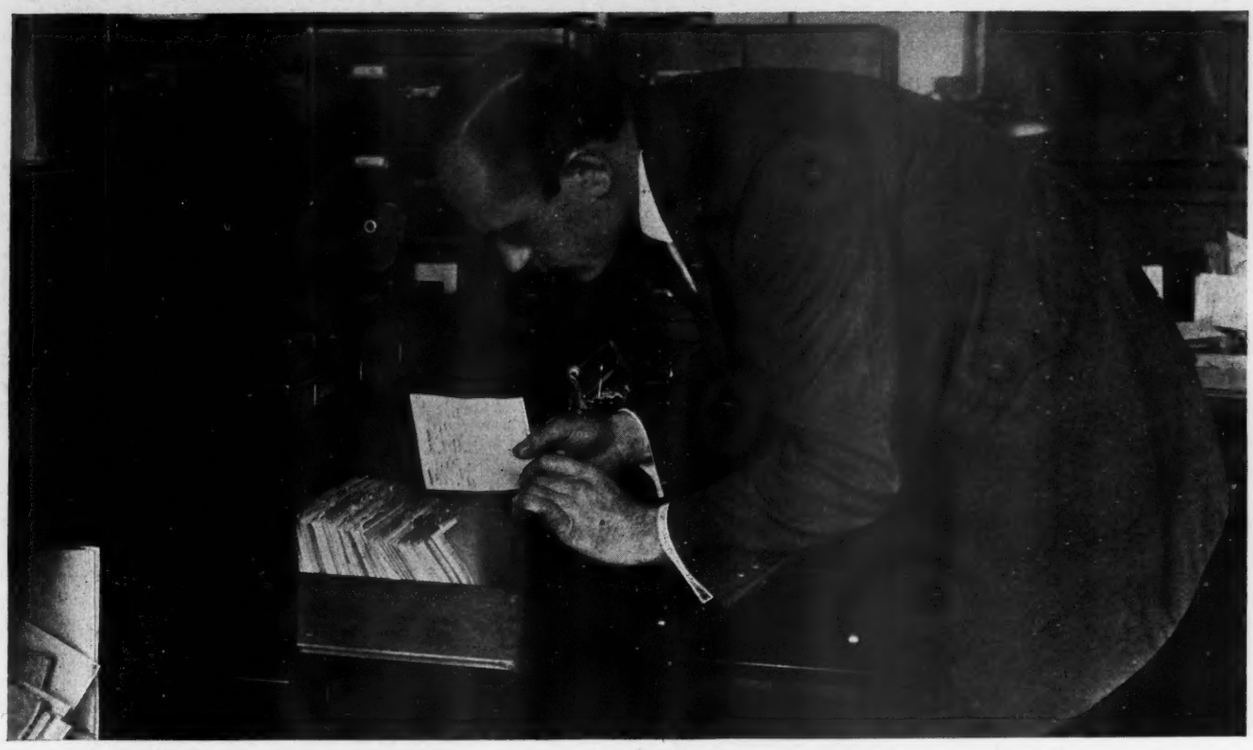
MODERN POLE TYPE



220,000 - VOLT

MODERN SUBWAY TYPE

MODERN INDUSTRIAL OUTDOOR SUBSTATION



This small cabinet holds all the records that are described in this article for electrical and other equipment in the various departments of a large industrial plant.

A Simple but Complete and Flexible System of

Equipment and Inspection Records

For Large and Small Mills and Factories to Prevent Delays and Save Money When Making Changes and Repairs

A CERTAIN AMOUNT of record keeping is essential in every well organized and smoothly operated factory or mill. Maintenance records that fall in the essential class show what equipment is installed and in stock, how equipment has been moved from one location to another, what spare parts must be ordered to replace worn equipment, and the like. Details are given in this article of the records kept in a large New England manufacturing plant, arranged so that they will be helpful to the electrical departments of other plants for the purpose of comparison with their own record system or as a guide for putting in a new system. The plant where this system is installed has 4,000 hp. in 440-volt, three-phase, alternating-current motors, installed and in operation. These motors include one 90-hp., one 40-hp., several 25-hp., but the majority are motors in sizes of 20-hp. and smaller.

TOO MUCH RED TAPE is a nuisance anywhere at any time and particularly in these days when operating and clerical forces have been reduced to a minimum. On the other hand, the waste from delays and confusion in handling repair work and changes, resulting when no order and record systems are kept, runs into large sums even in small plants. Some methodical record system of equipment and maintenance work is, therefore, essential in every factory electrical department making changes in the layout of apparatus and buying materials for stock.

In this article a simple system is outlined which can be modified to suit conditions and requirements in shops large or small. Besides enabling the head of the electrical department to be prepared for necessary changes and repairs when they are needed, it also enables the maintenance force to show the lowest possible cost of carrying on its work, through utilizing equipment that is available and carrying such parts in stock as will prevent delays when orders for repairs or changes are issued.

The electrical record system is part of a larger system which records every movable piece of equipment in the entire plant. This general system is called the plant register. Under this plan whenever a piece of equipment comes into the plant it is assigned a number by a record clerk. Numbers are given out in serial order regardless of the kind of equipment. For example, a desk for the office might be No. 1000 while an auto starter would be No. 1001. A brass plate with this assigned number etched upon it is attached to the piece of equipment in a conspicuous place. The equipment is then sent to the proper department. The records for the electrical apparatus are kept in the electrical engineer's office while those for other equipment are kept in the proper department.

When the electrical department receives a piece of equipment a card is made out showing the serial num-

ber of the apparatus and the kind designation as shown at *A* in Fig. 1. This is a 3-in. by 5-in. card and holds only a few details relative to a piece of equipment. It does show, however, where the equipment is placed, the department number, the building number, the floor and the date of installation. Below is space for the plant order and the purchase order. Sufficient space is left on the card to allow additional notations when the equipment is moved from one location to another. Other details will be given later of the procedure when making changes in the location of equipment. After this card is made out it is filed according to the serial number.

Descriptive Card for Each Piece of Apparatus Filed Under Its Name

A 5-in. by 8-in. card which contains complete descriptive information on the equipment is next made out. For most kinds of equipment, this card is drawn up in a rather simple form as shown at *C* in Fig. 1. The serial number is put at the left-hand corner and the kind of equipment is put at the right-hand top corner. Underneath is space for the department, building and floor numbers and for a more or less complete description of the equipment. This description usually consists of the nameplate data and any other information which may be necessary on the particular apparatus listed.

These apparatus cards are filed under a type classification of equipment. Some of the headings, for instance, are as follows: Motors, starters, switches, high-tension distribution wiring, low-tension distribution, substations, elevators, air system, etc. There is also the heading called "Stock" for equipment in the storeroom. The motor cards are filed under the heading "Motor" and this one section is subdivided into other sections corresponding to each department of the plant.

Full Information Is Kept on Motor Cards

For motors and desk fans, much more information is entered on the card than is entered for other equipment. Such motor cards, as shown at *B* in Fig. 1, bear the nameplate data, the size of the motor shaft, keyway and pulley and the size and speed of the driven pulley and the size of the belt. It also includes the nameplate data on the starter as well as the size of fuses used with the motor. Below this are spaces for installation date, date of removal and new locations of the motor. At the bottom of the card is shown the name and number of the machine which the motor is driving. On the reverse side of this card are entered notations of all repairs with the dates, the extent of the repair work and its approximate cost.

Fig. 1—Records which save time and prevent mistakes in the electrical department.

At *A* is the 3-in. by 5-in. serial card made out when a piece of equipment comes into the department. It is filed according to its serial number. The 5-in. by 8-in. card at *B* is the "equipment card" which is made out for a motor. This carries extensive information including name-plate data and details of drive and starter. A simpler card shown at *C* is used for other equipment than motors and desk fans. These cards are filed under a heading corresponding to the kind of equipment. The motor cards are further subdivided according to department. The form used for desk fans is shown in Fig. 2. The form at *D* is a 3-in. by 5-in. "notification-of-change" slip. It is filled in by the foreman who moves a piece of apparatus from one department to another.

Shop No. 7513
Name Motor G.E Type KT

Location:-Dept. No.	Bldg. No.	Floor	Date of Installation
DEF	34	1	3-8-19
Stock	34	4M	7-7-20
ABC	2	1	9-23-21

Plant Order 23972 Purchase Order 11213
Remarks:

A

PLANT REGISTER

NAME Motor NO. 7513

	DEPT.	BLDG.	FLOOR
OLD LOCATION	Stock	34	4M
NEW LOCATION	ABC	2	1

REMARKS

9-23 1921 By L.S. Jones

D

PLANT REGISTER — MOTOR

Shop No. 7513 Dept. ABC Bldg. 2 Floor 1 Location
20 H.P. 1160 R.P.M. Full Load 245 Amps. Per Term. 440 Volts 3 Phase 6 Poles
Make General Elec Co. Type KT Frame No. 322 Serial No. 12345
Motor Shaft 2⅞" x 6" Key ½" x ½" x 5½" Pulley 10" x 6¾" x 2⅝"
Drives To 50" x 8" Pulley Running at 230 R.P.M. Belt 29'-10" x 6" D
Starter: Shop No. 17580 Make General Elec Co. Type H5P1 Serial No. 1487092
Fuses: Running 65 Amp. Type E Starting Amp. Type
Date Purchased 12-1-18 Purchase Order 11213

Date Installed	Dept.	Bldg.	Floor	Date Removed
3-8-19	DEF	34	1	7-7-20
7-7-20	Stock	34	4M	9-23-21
9-23-21	ABC	2	1	

On reverse of this card note all repairs with date, extent of repair, and approximate cost.

B Connected to Lock Corner Cutter No. 115379

17580 PLANT REGISTER Motor Starter

Department No.	Bldg. No.	Floor	PLANT FIXTURES
9-23-21 ABC	2	1	G E. Type H5 P1 Serial No. 1487092
			20 Hp. 440 volt 3 phase
			60 cycles

C

How a Motor Is Found for a Rush Job

Another form of record is kept in order to show quickly where a motor may be found to fit a certain job in case there is a hurry call for it. This is a set of 3-in. by 5-in. cards kept at the front of the motor file. At the top of each card is a notation "Motor" and a certain horsepower rating, such as "7½ hp." On this card is listed the serial number of each motor rated at 7½ hp. and there is a card for every motor of this size used in the plant. These cards are used when a certain size of motor is needed and it cannot be found in stock. By consulting the cards it is found out which numbers designate motors corresponding to the horsepower desired. Then the serial file is searched for these numbers. When a motor is found which can be spared from the job on which it is operating, it is transferred to the particular job where it is most needed.

Another piece of electrical equip-

ment which is recorded with very complete data is the desk fan. The equipment card for a desk fan is shown in *B*, Fig. 2. This is a 5-in. by 8-in. card with space for the nameplate data and also the size of the fan, the number of blades, whether it is oscillating or bracket, the purchase date and the order and catalog numbers. Below is space for the date of installation and removal together with the department, building and floor.

Meters, instruments and the like are included under substation records. A section of the file is devoted to substations and contains cards for transformers, switches, relays, meters, and other instruments. These are not filed under the name of the equipment.

How These Records Are Used

Chief among the advantages of such a system of records is the ease and certainty with which spare parts may be ordered. If spare parts are needed for a certain machine or if a duplicate must be bought for use in a similar location, it is only necessary to consult the card and get the information. If a new starter is needed for a certain motor, the motor card will give full information. If the number of the old starter is known, the starter card may be consulted without reference to the motor card.

If a certain size of motor is needed to drive a machine, the cards in the stock file are examined. A motor with the desired characteristics is chosen from among these cards. If the exact size is not available the cards will show what sizes may be had.

Records Are Changed When Equipment Is Moved From One Place to Another

Whenever a piece of apparatus is to be moved from one location to another a verbal order is given by the head of the electrical department to the foreman in charge of the job. This verbal order is followed by a written order. After the equipment is moved, maybe to another department of the plant or maybe to the stock room, the foreman in charge of the moving makes out a "notification-of-change" slip such as shown at *D*, Fig. 1. This gives the name of the machine, its number, the old location and the new location. After the slip is signed by the foreman it is sent to the head of the department who has the change noted upon both the serial-number card and the equipment-record card. By this plan the cards are kept up-to-date.

Troubles Are Investigated and Remedied When They Appear

Although regular and frequent inspections are made of all equipment no written reports are turned in on such apparatus as motors, controllers, etc. Complete reports, however, are made on the high-tension equipment, meter readings, the transformer houses, and the elevators. Daily reports are made on the condition of the high-tension system in the substations. These are made upon blanks 8½ in. by 10¼ in. in size. Inspections are made three times a day. The inspector examines switches, transformers and switchboards. He notes the condition of disconnecting switches, primary oil switches, secondary switches, the level of the oil in the transformers and its temperature and whether switches are open or closed on the switchboards. If grounds are found they are reported to the electrician at once. Check marks are placed in the squares as shown in *A*, Fig. 2, to indicate normal conditions.

(Continued on page 216)

Fig. 2—Daily records of meters, substation apparatus and an equipment-record form for a desk fan. At *A* is a report of the inspections made three times a day in the substations. It records the condition of transformers, switches, switchboards, etc. At *C* is a daily report of meter readings. This is used to show the power consumption of different departments and also serves as a check to prevent the overloading of distribution equipment. The form at *B* holds rather complete data and space for recording several changes of location. It corresponds to the forms shown at *B* and *C* in Fig. 1.

DAILY REPORT OF HIGH TENSION SYSTEM INSPECTION

Trans. Hse. and No.	Round Number	Time	Power Off	Transformer Houses: Switches excluding Sec. Sws. or Switch Boards: Dis.	Prim. Oil	Sec.	Transformers: If Low Oil Level Number Inches: AB	BC	CA	Temperature Degrees Centigrade: AB	BC	CA	Remarks	Switch Bds.: Switches Open or Closed, Oil Level, Temperature, Recession	Grounds Found, Reported, Cleared	Remarks
No. 1	1	A.M.	P	✓	✓	✓	✓	✓	✓	51	51	52		B		
			L													
	2	A.M.	P	✓	✓	✓	1/8	✓	✓	58	59	59		B		
			L													
	3	P.M.	P	✓	✓	A	✓	✓	✓	63	65	64		B		
			L													
		P.M.	P													
			L													

A check (✓) indicates that conditions are normal. If conditions are abnormal insert a letter referring to a complete report on the other side of this sheet.
GROUNDS must be reported to the Electricians at once. On opposite side of this sheet complete information must be given as to location, cause, time reported and time cleared. The Inspector will obtain this information from the Electricians.
If a round is omitted for any reason, give reason on proper line.
Inspected by: *A. R. Hunter* Day: *4-6-22*
Examined by: *M. S. Clements* Date: *4-7-22*
If everything is normal put "O. K." in square in corner. Otherwise insert cross [X]

A

PLANT REGISTER

DESK FAN — MOTOR

Shop No. | Dept. | Bldg. | Floor | Location
Nom. Size | No. Blades | Oscillating or Desk and Bracket (Cross out one)
Make | Style | Form | Serial No.
Watts. Fast Speed | R. P. M. Fast Speed | Volts | Phase | Poles
Date Purchased | Purchase Order | Cat. No.

Date Installed	Dept.	Bldg.	Floor	Date Removed

B On reverse of this card note all repairs with date, extent of repair, and approximate cost.

DAILY REPORT OF POWER AND LIGHT READINGS

LOAD AND VOLTAGE READINGS

Item No.	ITEM	Switchboard Number 1	2	3	4	5	6
	TIME OF READINGS	9:22 A	9:48	10:16	10:50	11:10	11:38
	POWER						
1	Volts, Phase AB	442	441	441	440	440	442
2	" " BC	442	442	442	441	441	442
3	" " CA	441	442	442	442	441	442
4	Amps. Phase A	532	107 2	78 5	6 3/4	17 3	12 7
5	" " B	52 2	107 3	78 6	6 3/4	17 2	12 7
6	" " C	54 2	107 2	78 5	6 4 5	17 5	12 7
7	Kilowatts	32 5	80	57 0	4 25	26	120
8	K. V. A. = VOLTS × AMPS. × 1.73 / 1000	406	773	600	500	132	143
9	Power Factor = K. W. / K. V. A.	80	75	85	81	73	70
	LIGHT						
10	Volts, Phase AB	111	111	110	111	111	111
11	" " BC	111	111	111	111	111	111
12	" " CA	111	111	111	111	111	112
13	Amps. Phase A	36	200	25	150	36	225
14	" " B	36	218	2	100	60	230
15	" " C	35	167	32	100	50	220
16	K. V. A. = VOLTS × AMPS. × 1.73 / 1000	7	43	3.5	19	7	43
17	K. W. = K. V. A. × 0.95	6.6	41	3.3	18	6.6	41

POWER AND LIGHT CONSUMPTION

Item No.	ITEM	Switchboard Number 1	2	3	4	5	6
	TIME OF READINGS	9:20	9:45	10:15	10:48	11:05	11:33
	POWER						
18	W.H.M. Reading To-day	3531	10720	06002	21723	67466	12550
19	" " Yesterday	3563	10672	05962	21572	67388	12678
20	K.W.H. = (18-19) × Const.	2,800	4,800	4,000	3500	770	1520
	LIGHT						
21	W.H.M. Reading To-day	87717	10051	09628	36388	25947	26245
22	" " Yesterday	87762	10005	09627	36367	25933	26211
23	K.W.H. = (21-22) × Const.	150	460	100	210	140	340

SUMMARY

Item No.	ITEM	Total of All Switchboards: K. V. A.	K. W.	P. F. (Figured)	K. W. H.		
24	Power	2554	2016	78	17,400		
25	Light	123	117	95	1,400		
26	Total	2677	2133		18,800		
27	Total Yesterday	2432	1886		17,100		

REMARKS:

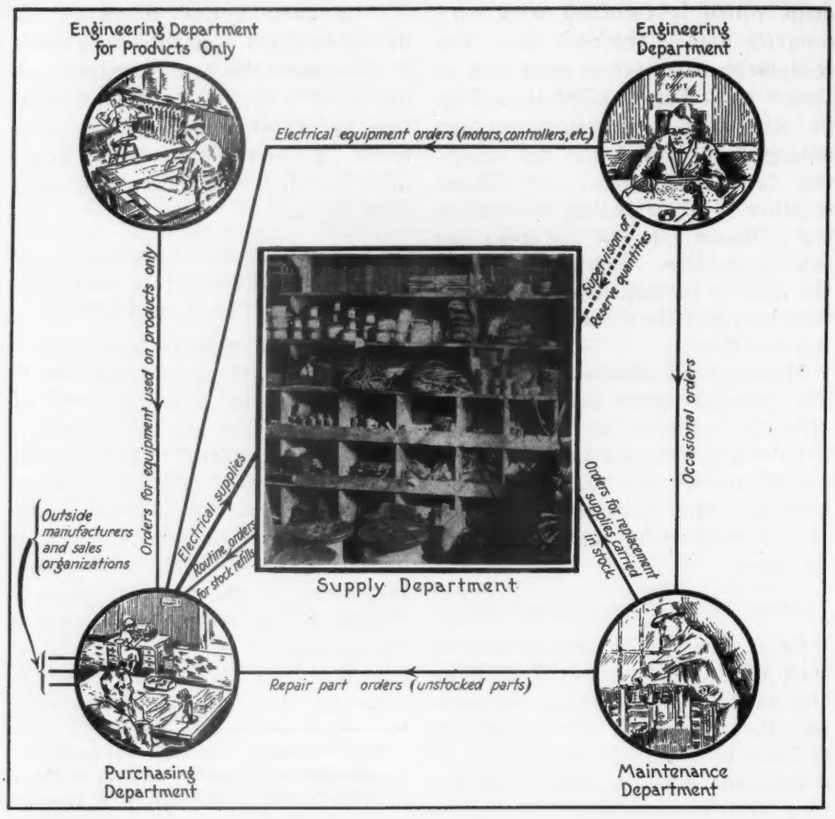
READINGS BY: *F. L. D.* DAY: *3-28-22*
PLOTTED BY: *Mott* DATE: *3-29-22*

C

How Complications Are Eliminated

When Ordering Electrical Supplies

in Large Volume for Use as Parts in the Assembling of Machines



IN AN industrial works where electrical equipment is purchased for use as parts in the assembly of the product made as well as for the general maintenance of production processes, there is ample opportunity to build up intricate and expensive ordering and stockkeeping systems. To reduce such systems to their simple elements and so maintain them, is often a larger problem than the routine job that is involved in making available the supplies that are regularly needed. An interesting example of an effective and extremely simple purchasing system is found in the plant of the Brown & Sharpe Manufacturing Company at Providence, R. I. Here a diversified product is made calling for engineering supervision and much research at times in adapting the required motors and control equipment and other electrical equipment to the service that the machine must furnish. In addition, there is a group of widely distributed buildings where electrical apparatus is extensively used and carefully maintained to insure continuity of production processes.

Electrical equipment and supplies are purchased in this establishment, therefore, from two viewpoints: (1) For use as parts to be assembled on the machine tools manufactured by the company; (2) for maintaining electric service in the plant. In regard to the first, it is sufficient to state that the responsibility for such purchases rests with the designing and production engineers, who are not concerned with plant engineering. The electrical equipment used on machines is ordered through the purchasing department along the usual lines of practice, and except that some of the motors and wiring supplies may be stored within the same walls as electrical equipment selected by the engineering or maintenance departments, there is no overlap in activities. It goes without saying that conferences on engineering subjects may be held as occasion requires between any of the engineering forces of the company, but the chief interest in this article is devoted to the arrangements by which the necessary plant supplies and equipment for all purposes are usually bought.

WHEN MANUFACTURING a product that uses electrical equipment as a component part, service requirements from the standpoint of design and machine production often modify the ordering and stockkeeping system from that required to maintain electrical equipment used in the operation of production processes. Here is an interesting example of a simple system used in the large works of a well-known machine tool manufacturer.

Close co-operation in the work of the engineering and maintenance departments is a striking feature of the purchasing scheme. The former department, as its name implies, exercises a general technical supervision of the plant, studies the problems of equipment selection from the economic standpoint, investigates nonroutine matters, conducts researches, and in a broad way does planning and construction work. The maintenance department, on the other hand, looks after plant inspection and repairs and in the main handles the routine problems of keeping the equipment fit for efficient service.

All routine purchasing of supplies is handled by either the supply department or by the maintenance department working through the purchasing department, which maintains official contact with the outside for all factory purchasing, as is usual in industrial organizations. Confer-

ences for the purpose of securing information and interchange of ideas take place from time to time between interior departments and outside organizations; but the actual placing of orders, whether by the request of the engineering or other internal branches, is done by the purchasing department. This department also follows up progress, shipments, receipts and disposition of material after arrival at the factory.

As a result of experience and of studies by the engineering department, supplemented by the reports of the maintenance department, certain quantities of electrical supplies, such as fuses, lamps, and wire are normally kept on hand by the supply department. As these quantities become reduced in stock, this department automatically requisitions material for refilling its bins and shelves by an order on the purchasing department. The maintenance department draws upon the supply department reservoir of material for current needs without going to the purchasing department for what in the electrical jobbing field would be classed as fast-moving material.

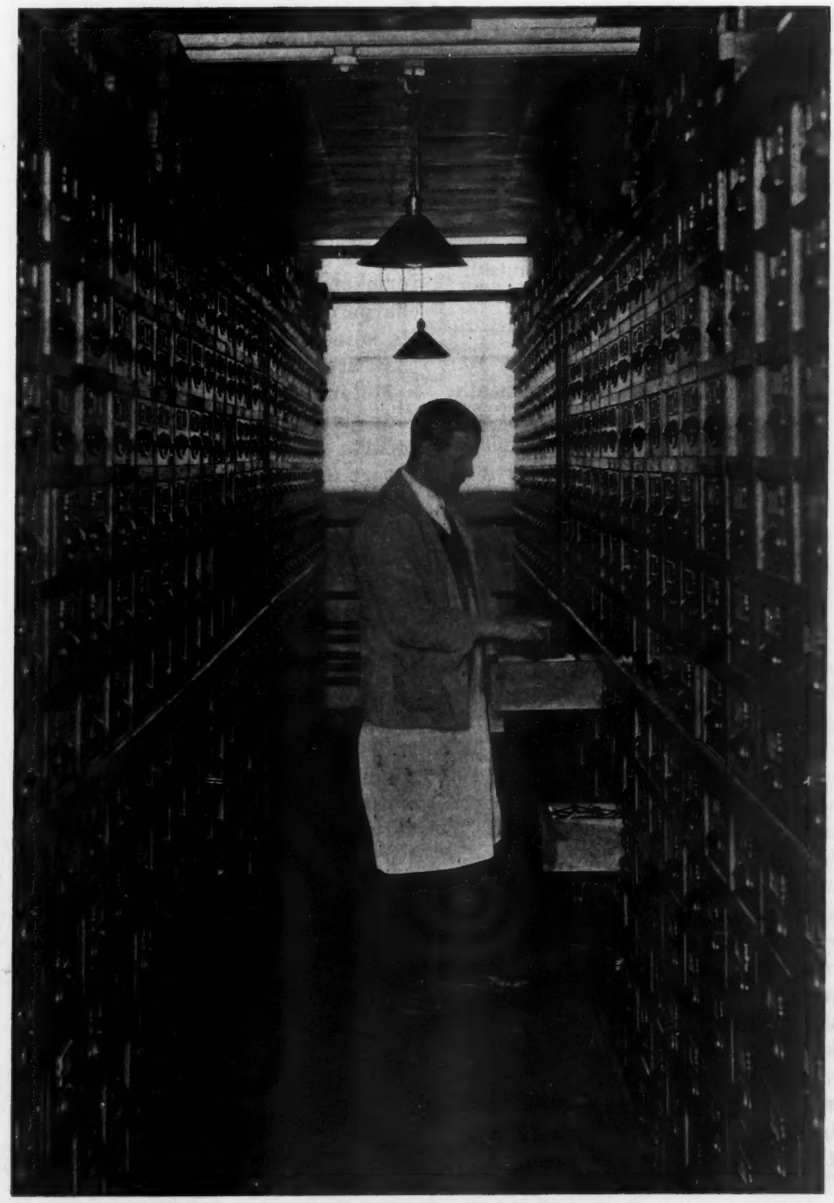
Routine Buying by Maintenance Department

The maintenance department orders repair parts of electrical control apparatus and of motors or other repair material not normally carried in routine stock, directly through the purchasing department. Replacement parts do not involve analytical engineering consideration before purchase, so that the maintenance department logically handles such orders. In some cases, largely as a matter of convenience, the engineering department requests the maintenance department to order certain material which it is planned to try out, but as a rule new development work is ordered through the purchasing department. In case a section of the factory were to be equipped with motors and lamps, the engineering department would take up the problem of motor selection and the maintenance department would order the necessary lamps direct from the purchasing department unless a new problem in illuminating engineering were involved. In such event, the investigations to determine the type and size of lamp to be employed would be carried on under the general supervision of the engineering department. But any suggestions or aid which might be given by the maintenance department would be welcomed.

No rigid line is drawn between the internal activities of these departments as regards following up new installations or carrying forward the factory equipment service to the plane of maximum efficiency, barring the purchase of motors and equipment as distinguished from supplies by the engineering department and certain steam plant administration. The maintenance department is at all times responsive to the engineering department's orders and investigates equipment performance and reports to the latter department as required.

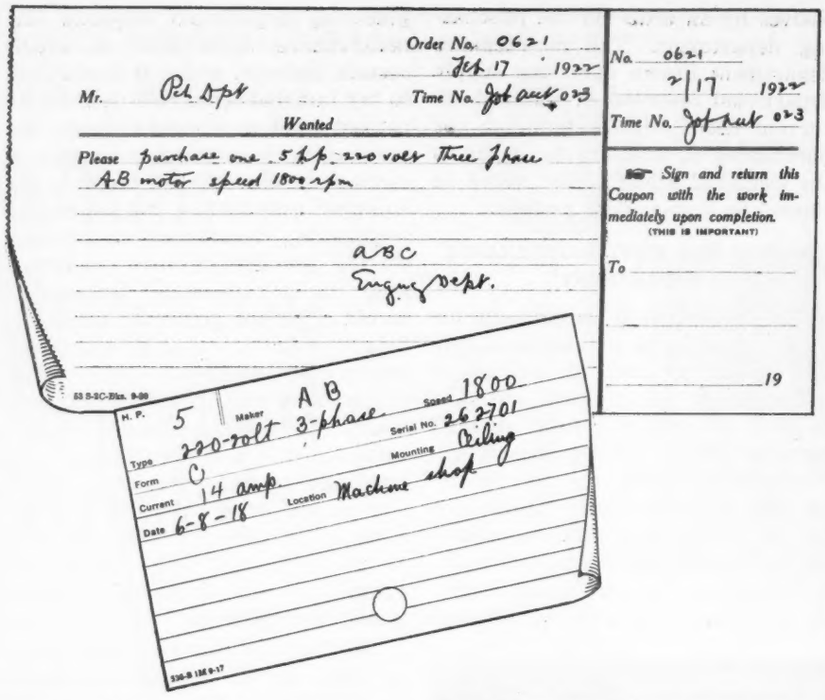
Ten Per Cent Motor Reserve

The electrical stock room shares the quarters of the general supply department. Motors are stored in a separate room together with control apparatus and some other supplies. In this plant the keeping of spare motors is based on an average of about 10 per cent of the number of motors in service. A minimum of one spare motor is kept in all sizes, but experience has shown the wisdom of a 10 per cent stocking. In case of motor trouble the problem is to withdraw the motor and substitute another in the shortest possible time rather than carry out the necessary repairs in the speediest possible manner. Group driving is extensively used and the maintenance of machine tool production is the



Stockroom for small electrical supplies.

Such material as fuses, switches, knobs, tubes and the like is stored in drawers of the type shown. This arrangement places thousands of spare part units within reach of a single attendant.


Order No. 0621
Feb 17 1922
Mr. Pat Dept
Time No. Jot ank 023
Wanted
Please purchase one 5 hp 220 volt Three phase AB motor speed 1800 rpm
a B C
Engine dept.
No. 0621
2/17 1922
Time No. Jot ank 023
Sign and return this Coupon with the work immediately upon completion.
(THIS IS IMPORTANT)
To
19
H. P. 5 Maker A B Speed 1800
Type 220-volt 3-phase Serial No. 262701
Form C Mounting Ceiling
Current 14 amp Location Machine shop
Date 6-8-18

This Illustration shows motor purchasing form and a motor record form.

The purchasing form carries an order blank and a stub at the end that is torn off and returned to the originating department. A yellow duplicate is filed at the originating office for reference. Two sets of motor information cards are used. One is filed according to motor sizes and the other according to motor locations, in order to check up quickly the number and sizes of motors on hand.

primary object of the maintenance department instead of high-speed repairs.

There are no unusual features about the storing of electrical supplies, but coils of wire are conveniently stored on ¾-in. inclined pipes set into walls or posts to form pins. Loom, flexible armored conductor and flexible tubing are also stored in a similar way.

Two Motor Record Cards Are Used

A convenient motor record card, shown in an accompanying illustration, is used. Here the object is to keep the cards as simple as possible. Two sets of motor cards are maintained. One is arranged according to motor sizes and the other according to motor locations. This system of cross-referencing enables the number of motors of a given size and type in service to be checked up very quickly, and also facilitates "spotting" motors in case changes are being studied.

Interdepartmental records and forms bearing upon electrical purchasing are little used, and the amount of clerical work required in this connection is very small. Copies of written orders from the engineering department to the maintenance department or purchasing department are, of course, kept on file in the originating office. But nothing like the elaborate forms sometimes found in industrial establishments is deemed necessary at Brown & Sharpe's electrical division. A convenient form is used in purchasing which carries the order and a stub at the end that is torn off and returned to the originating department by the purchasing or other department handling it when the order is completed. A yellow duplicate is filed at the originating office for reference.

As a result of the intimate relations between the engineering and other departments having to do with furnishing of electrical supplies and equipment, and of the freedom from complication secured by the arrangements above outlined, the buying of supplies is done upon a sound technical and operating basis and yet with so little external evidence of activity that it is most effectively accomplished. Buying by qualified engineers and maintenance heads working together in this manner appears to insure reliable equipment and material service, comprehensive knowledge of the performance of supplies, and a basis for research which is broad enough to cover all branches of electrical service within the establishment.

Equipment and Inspection Records

(*Continued from page* 213)

If not normal a letter is inserted referring to a complete report on the back side of the sheet.

Daily reports are turned in showing the readings on the meters of all switchboards. These are shown in *C*, Fig. 2. Volts, amperes and kilowatts are read on all phases and kilovolt-amperes and power factor are calculated and entered. These readings are put down for both power and light circuits. Watt hour-meter readings are also entered.

An interesting feature of the blank forms used consists in small figures printed in the squares in which the readings are entered. These small figures indicate the full-scale reading of the meter. They serve as a check when the inspector is entering his readings and also when the head of the department is studying them after they have been turned in.

All elevators are given a complete inspection at least once a month. The reports are made up on a special form and handed in to the man in charge of the electrical department. He notes any troubles and sees that they are removed.

Motors are inspected from once to four times each day, but no written reports are made. The inspectors report to the foreman in charge of inspection whenever troubles are found. The inspectors themselves either remedy the trouble immediately or, if it is beyond their power, they call on the foreman. If he cannot cure it he reports to the man in charge of the electrical department who takes steps to remove the trouble. When necessary a graphic watt meter is put on the machine giving the troubles and records are taken. After these records have served their purpose they are filed permanently in chronological order.

Each blue print of a machine, wiring, control aparatus, etc., is given a serial number and filed according to this. Two 3-in. by 5-in. cards are then made. One of these is filed according to the location of the apparatus or equipment which is shown on the blue print. The other is filed according to the subject, such as motor foundation, low-tension wiring, switchboard, and so on.

Synchronous Motor Troubles—

Diagnosis and Remedies

Compiled by H. E. STAFFORD

Electrical Engineer,
Provincial Paper Mills,
Port Arthur, Ont.

(This table is continued on page 257)

SYMPTOM	TROUBLE	CAUSE	REMEDY
Bearing too hot to touch or smoking.	*A* Bearing dry.	Not sufficient oil; oil rings not working.	Refill with clean oil after first washing bearing with kerosene
	B Bearing dirty.	Grit in oil.	Same as above.
	C Bearing tight.	Cause 1 and 2 above causing particles of metal to be sheared off and deposited at other parts.	Scrape bearing and shaft or replace bearing.
	D Oil rings not working.	Rings out of slots.	Replace rings, making sure no metal adheres to sides of slot
			If ring sticks or runs slowly, bevel it at either top or bottom with a fine file.
	E Bearing binding.	Shaft out of true.	Place shaft in a lathe and true and renew bearing.
	F Bearing out of true.	Too much strain on pulley.	Bearing should be shimmed with pieces of tin, as a temporary measure, or replaced with new bearing.
	G Loose bearing.	Vibration.	Tighten set screws holding bearing in journal.
2 Bearings hot, but no hotter than other parts of motor.	Heat transferred from rotor or stator windings of motor.	*A* Overload on motor.	Decrease load or increase size of motor.
		B Motor field overexcited.	Decrease strength of field by lowering excitation.
3 Stator windings hot at certain spots, enough probably to cause smoking. Wedges over coils charred.	Displaced air gap or rotor not centered in stator.*	Bearings worn on one side.	If noticed before coils are damaged, realigning the bearing and inserting new wedges will correct the fault; otherwise coils will need to be replaced.
4 Motor fails to start.	*A* Not sufficient torque.	*A* Voltage too low.	Increase line voltage. The torque is increased or decreased as the square of the applied voltage, i.e., if the voltage is doubled the torque is increased four times. Raising the compensator taps may help if the motor is not too large, but as this also increases the starting current, it tends further to decrease the voltage.
		B Open circuit in stator windings, due to a short circuit, rough handling, or wrong connection.	Repair break by "jumping" the coil† or coils causing the trouble, or else by replacing damaged coil.
		C Friction of bearings too great.	Scrape or replace bearings if frozen or relieve pressure between bearing and shaft by loosening journal studs.
		D Mechanical load too great.	Remove part of load or install clutch coupling between motor and load.
		E Wrong connection in compensator. One phase usually reversed.	Make proper connection in compensator.
5 Motor starts but fails to come up to speed.	Not sufficient torque.	*A* Rotor field in circuit with exciter, due to discharge switch being in wrong position. This creates a separate flux which opposes the alternating flux in the stator windings.	Open the circuit between exciter and motor field.
		B Mechanical load too great.	*A* Open discharge resistance. Care must be exercised in employing this method and resistance circuit must be closed before shutting down, otherwise field winding may be damaged.
			B Raise the line voltage.
			C Increase the squirrel-cage winding on the rotor.
			D Install a clutch coupling.
		C Not enough bars in squirrel-cage winding.	Same as above.
6*A* Motor comes up nearly to synchronous speed but cannot be thrown on line.	Trouble in exciter circuit.	*A* Open circuit in rotor field.	Test out with low voltage or magneto, and repair break.
B Motor fails to synchronize.		*B* Open circuit in exciter field.	Same as above.
C Circuit breaker trips out when line voltage is impressed on motor.		*C* Open circuit between exciter and motor field.	Same as above.
		D Open circuit in exciter armature. The circuit between rotor and exciter is not broken in a case of this kind, but the current is interrupted and decreased.	Bridge the open circuit by connecting a piece of wire to commutator bars each side of break
		E Faulty brushes on exciter causing the same trouble as above stated.	Adjust brushes if out of line, renew if broken or worn, increase tension between commutator and brushes and clean commutator.
		F Open circuit in motor field rheostat.	Test with magneto and repair break.
		G Open circuit in exciter field rheostat.	Same as above.
		H Field-discharge switch fails to make proper contact.	Clean contacts or, if badly pitted, renew.
		I Short circuit in one or more field coils.	Test with low voltage and compass and repair or renew damaged coil.
		J Reversed coil in rotor field circuit. A fault of this kind cannot happen while motor is running but would be due to a wrong connection while repairs were being made to the rotor. All the other faults could however happen while the motor was running due to careless operation or foreign material being drawn into motor by suction or by damage to the exciter and wiring.	Test with low voltage and compass and reverse connections on coil causing the trouble. Note: In connection with the above two remedies, low direct current voltage is applied to the field windings and a compass held to each pole. In case of a short circuit, the short circuited pole will give no deflection of the compass. With a reversed coil the deflection is opposite what it should be, in other words, instead of adjacent north and south poles there will be two north or two south poles together.
7 Stator windings hot at all parts.	*A* Mechanical overload.	Mechanical overload.	Remove part of load or increase size of motor.
	B Low power factor.	Over-excitation of field coils. The low power factor in this case is leading and has the same effect as low lagging power factor since the current and voltage are out of phase in the same proportion.	Adjust field excitation until the current in the stator is minimum. This will increase the power factor of the motor but will lower the power factor of the system.
8 One or more coils in stator so hot that insulation is completely burned off.	Short circuit in one or more coils.	Due to mechanical injury or to broken down insulation due to an overload.	"Jump" the injured coil† as a temporary expedient or replace with a new coil.
9 Motor issues a peculiar humming sound which increases and decreases in volume at certain intervals. Motor may even slow down and stop or trip circuit breaker in a case of this kind.	Motor "hunting."	*A* Unstable speed of prime mover on alternator supplying motor.	If speed of prime mover cannot be properly regulated adding more squirrel-cage windings will correct the fault.
		B High resistance in line between alternator and motor due to long transmission line.	The same applies where "hunting" is due to resistance of the line.

* As the air gap of a synchronous motor is relatively large, this trouble is seldom met with although the bearings may become worn.

† Care must be used in "jumping" a coil, and the following points should be observed: Where a phase-boundary coil is cut out or "jumped" care must be taken that no interconnection of phases or wrong groups takes place. In one-layer windings, if the insulation is badly burnt, the coil will have to be completely taken out, since, if only disconnected, circulating currents will be produced which will heat up the "jumped" coil and damage adjacent coils. This is due to there being only one coil side per slot. If more coils than one per phase are burnt, care must be taken that there are enough left to offer enough resistance to keep the current low. If too many are cut out the remainder may heat excessively.

IN MAKING WELDS which will stand up in service, three things are essential: (1) Careful preparation of the parts. (2) Skill in the manipulation of the arc. (3) A thorough knowledge of the thermal effects produced by the welding process. In this article Mr. Wanamaker takes up each of these points from the practical standpoint of the welder and outlines in detail the methods and procedure which are followed in the Rock Island shops for making different welds on a wide variety of iron and steel parts.

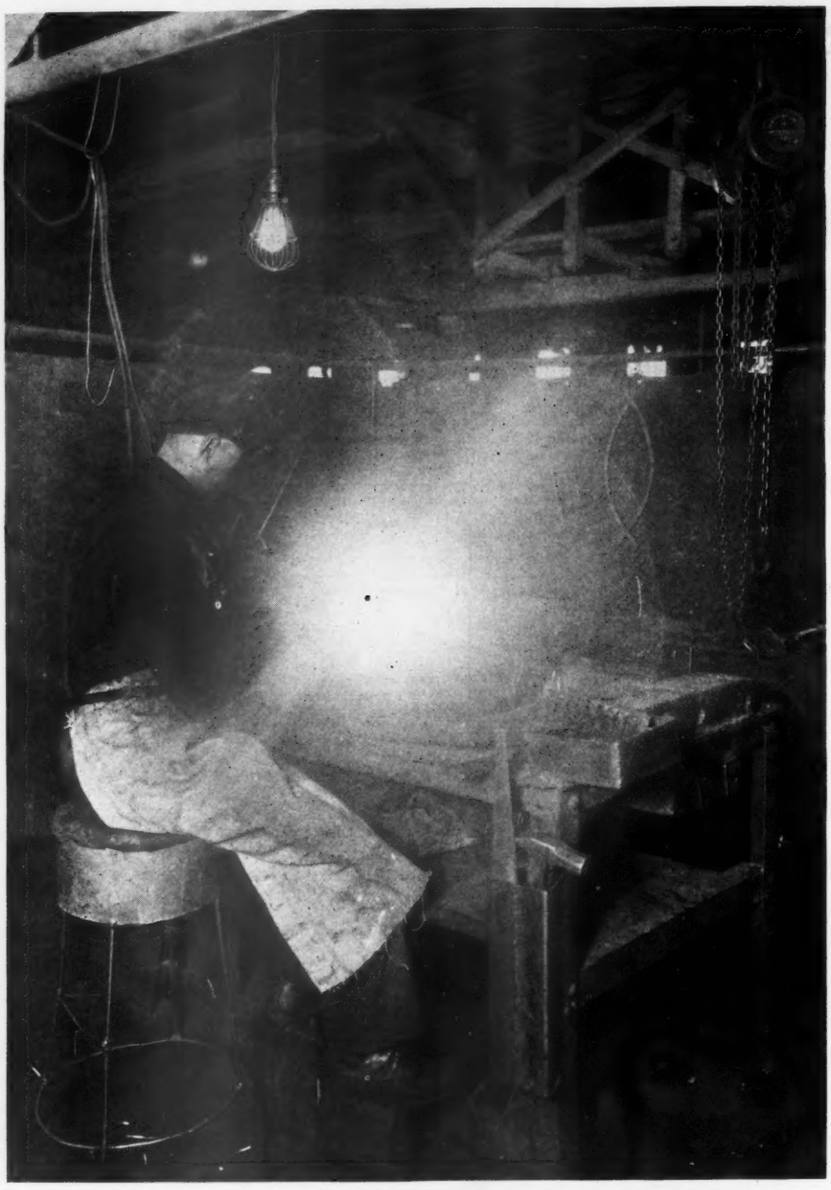
Things Operators Should Know

When Welding Iron and Steel

and the Procedure Followed in the Rock Island Shops

By E. WANAMAKER

Electrical Engineer, Chicago, Rock Island & Pacific Railroad



The operator is shown here in a special welding booth working at a sheet- and angle-iron bench. A heavy duck curtain serves to shield the arc from air drafts and protect nearby workmen from the arc glare.

IN THE APRIL issue of ELECTRICAL REVIEW AND INDUSTRIAL ENGINEER the writer outlined the general procedure governing the use of electric arc welding for repair and maintenance work in the Rock Island shops. Inasmuch, however, as every welding job presents different problems and, generally speaking, must be considered by itself, this article will take up the details of some of the procedure in repairing broken equipment or building up worn parts by the use of the electric arc.

The ability to make uniformly good welds requires a thorough understanding of the principles involved, supplemented by the training and experience necessary to give the requisite skill in manipulation. In electric welding the heat required for the fusion of the metals is obtained by the transformation of electrical energy into heat liberated by an arc. An arc is produced when the two wires of a circuit carrying a heavy current are touched together and then separated a short distance. The ends of these wires are heated to an incandescent vapor which, with tiny globules of liquid metal derived from the wires, conducts the current from one wire, or electrode, to the other. The terminal from which the current passes into the vapor is called the positive electrode or anode, while the terminal to which the current passes is called the negative electrode or cathode.

In metallic-arc welding, liquid metal is transferred from the wire electrode to the work through the arc stream. The transfer takes place regardless of direction, whether downward or upward, and the force responsible for it has been the subject of much investigation. Present theories attribute the transfer of the metal (1) to molecular attraction; (2) to expansion of gas formed from the elements in the arc terminals, and (3) to condensation of metallic vapor formed from the electrode and the part being welded.

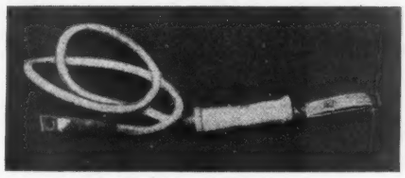
As was noted in the previous article, approximately 75 per cent of the total heat is liberated at the anode. The remaining 25 per cent of the heat is in the vapor and at the cathode. Inasmuch as the mass of the welding wire is usually less than the mass of the work, so that the

amount of heat lost by conduction is greater on the latter, it is usually made the positive pole. In some cases, however, as when welding very thin sheet metal, the wire electrode is made positive in order to reduce the tendency of the arc to burn through the sheet metal. Also when using certain electrodes, such as high-carbon or high-manganese, better results are obtained by making these positive. A special low-voltage generator is used to supply the electrical energy. A description of the style of generator and electrodes used on the Rock Island lines was given in the previous article.

The electrical connection to the work piece may be made by means of a clamp, which should be firmly attached, as a bad ground connection will increase the difficulty of performing a good weld. A carriage screw type of clamp with 4-in. opening is suitable and the ground wire should be securely fastened to it. The surface of the part where the clamp is attached must be perfectly clean. If a clamp is not available, the ground wire may be attached to a plate and the plate tack-welded to the work. It has been noticed that the arc is less erratic if the welding progresses away from the ground connection. Therefore, when possible, ground connections should be so located as to permit this procedure.

When welding, the electrode is gripped in a holder which is connected to the generator by a flexible cable. The electrode should be held firmly in order to prevent heating at the point of contact with the holder. The holder should be cleaned with a file every day or two at the point where it grips the electrode.

It may be mentioned here that the electric arc emits a large quantity of ultra-violet and infra-red rays, which are dangerous to the eyes unless they are protected by proper glasses. A widely used combination consists of one bright green, one or two ruby and one clear strip of glass mounted together. The present standard dimensions of the glass for a hand or helmet type shield are 2 by 4⅛ in., single strength thickness. The clear glass is used to protect the other from flying particles of hot metal and when it becomes pitted should be renewed, to keep vision clear.



This is a handy type of metallic electrode holder.

The electrode is gripped between two jaws held together by a stove bolt. A curved steel spring which bears on the upper jaw and can be adjusted by the bolt, produces the desired tension on the electrode. The handle is made of maple and a 3-in. fiber shield protects the operator's hand from the heat.

Protection From the Rays Given Off by the Arc

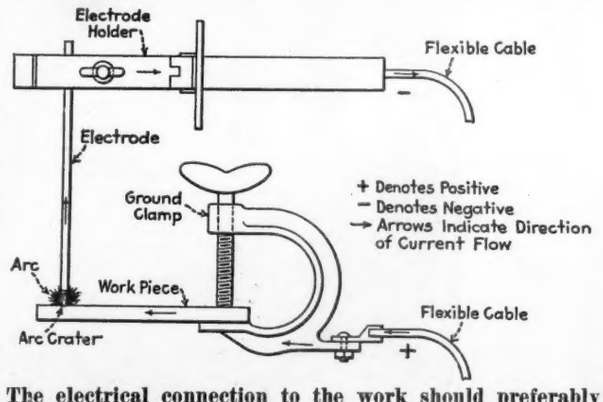
If any part of the body is exposed to the direct rays of the arc, the skin will be burned similarly to an intense sunburn. For this reason the shields in which the glasses are mounted are designed to cover the face completely. Both the hand and helmet types of face shield are used. The helmet type shield is required on some classes of work, such as boiler work, where it is often desired to have one hand free to steady the body, or for other service. Ordinary gauntlet gloves and closely woven work shirts or overall jackets will furnish ample protection to the operator from the light rays and flying sparks.

When much welding is done in one location a welding booth should be provided, in order to prevent the flashes from confusing men working in the vicinity. For short jobs portable shields should be provided to surround the welding operator. The shields will also protect the arc from strong air drafts, which increase the difficulty of arc manipulation, and should be painted black in order to minimize the reflected light.

Skill in Arc Manipulation Essential to Good Welding

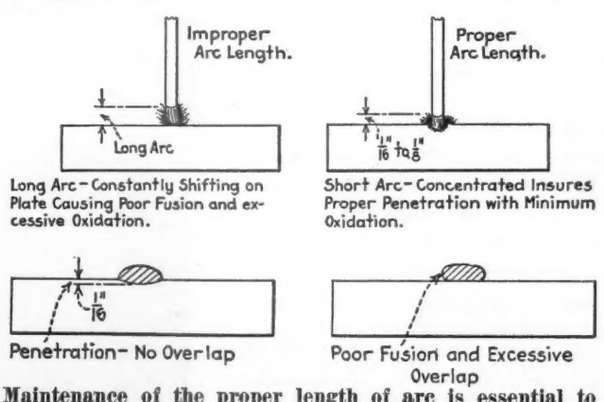
Acquiring the knack of arc manipulation is the first important step in the training of an operator, as the skill with which he is able to do this will largely determine the quality of weld produced. The electrode holder should be held in one hand and to avoid nervousness the grip on the handle should be very light. If the handle is held tightly the hand will shake and increase the difficulty of arc control. The problem is to acquire absolute control of the arm and the hand manipulating the arc, and this is best done by steadying the body, either by taking a sitting position, or if conditions require the operator to weld in a standing position, the knee, hip, or shoulder may be rested against something to brace and steady the body.

To start the arc the electrode is touched to the work with a dragging motion and immediately withdrawn



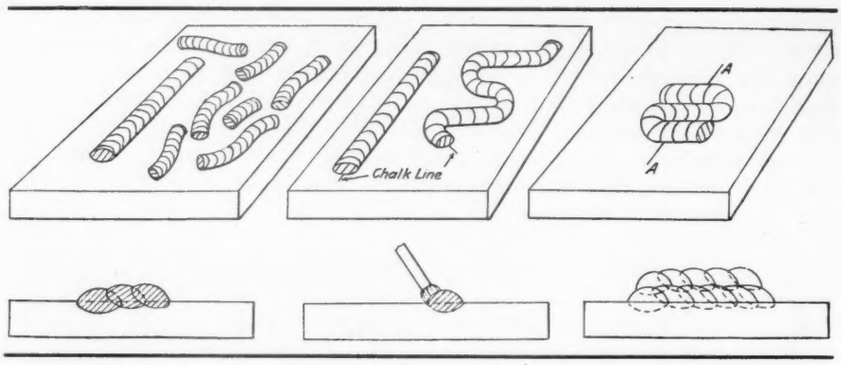
The electrical connection to the work should preferably be made by means of a clamp.

Unless a good ground connection is made it is very difficult to produce a good weld. The surface of the work must be well cleaned before the clamp is attached. As the illustration shows, the parts to be welded are usually made the positive pole, hence the current flows from the parts to the electrode.


Improper Arc Length.
Long Arc
Proper Arc Length.
1/16 to 1/8
Long Arc - Constantly Shifting on Plate Causing Poor Fusion and excessive Oxidation.
Short Arc - Concentrated Insures Proper Penetration with Minimum Oxidation.
1/16
Penetration - No Overlap
Poor Fusion and Excessive Overlap

Maintenance of the proper length of arc is essential to good welding.

Withdrawing the electrode too far from the surface of the work results in a long arc, but does not give the proper fusion and penetration. In addition the metal deposited by a long arc is more highly oxidized and thus inferior in quality to that deposited by a short arc.



These exercises help the operator to acquire skill in the manipulation of the arc.

As a start (upper left) layers should be put down on a flat plate until the operator can deposit a smooth layer 8 in. long without breaking the arc. Straight and crooked chalk lines should be drawn on a plate and layers deposited along these lines (upper middle) until the operator can follow them closely while holding the arc. Next a pad (upper right) should be put down with the layers overlapping as in the lower left illustration. When a pad about 6 in. long has been deposited, the scale should be removed with a chisel or sand blast and a second pad (lower right) put down on the first. By cutting through the pad and plate and polishing the ends the soundness of the deposited metal may be determined. The lower middle illustration shows the angle to hold the electrode for securing proper fusion.

about ⅛ in. It should be slightly inclined from the vertical. As melting begins, the electrode should be fed forward to maintain the ⅛-in. arc length, and at the same time moved along the surface of the work at a uniform speed. As welding is but successive baths of molten metal, one fused to the other, the arc length, arc current, and speed of arc travel must maintain the molten spot on the part being welded, in order that thorough fusion may be obtained between it and the molten metal from the electrode. When the operator succeeds in starting and maintaining a short arc length for some time, further practice should consist of forming a series of deposits until he is able to put down a number of straight smooth surface layers. This should be repeated while following chalk marks, in order to develop ability to follow a prescribed course. The width of the deposit can be varied over a considerable range by describing the arc of a circle with the end of the electrode as it is moved along the surface of the part. This procedure also assists in floating the slag to the top of the weld.

The angle at which the electrode is held with relation to the surface of the work, as well as with respect to direction of arc travel, will influence the penetration and ease of directing the flow of metal from the electrode to the point desired in the weld. It is difficult to give accurately the proper electrode angles for the various conditions. In general, the best results seem to be obtained when the electrode is slightly inclined, approximately 20 deg., from a line drawn at right angles to the face of the weld.

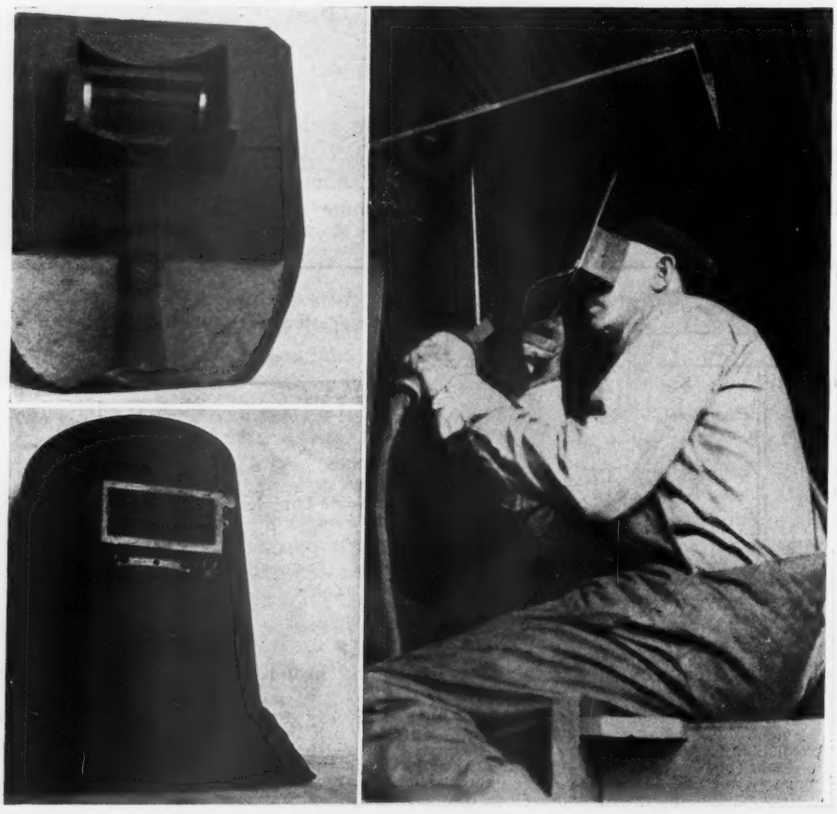
When parts are joined by welding, the joint is usually arranged to form a "V"-shaped opening, into which metal is fused to effect the union. The "V" may be formed by beveling the edges that form the joint or seam; or the position of one part with respect to the other may be such as to form a "V" without beveling the edge.

The manner in which the metal is fused in an opening so formed will determine to some extent the strength and quality of the weld, and experience has shown that a stronger joint is obtained when the course of the electrode is back and forth across the "V" to be filled. The course of the electrode to allow this procedure for joints or seams in the different positions is shown on page 221.

Welding Should Always Be Done With a Uniform Short Arc

The evident purpose of welding is to affect by fusion a perfect union between the metals to be joined. To do this it is necessary that the metals forming the arc terminals at the point of arc contact be heated to a liquid state and that impurities, such as oxides, be eliminated in so far as is possible. The fusion and the elimination of impurities are accomplished to the greatest degree by using a short arc, approximately 1/16 to ⅛ in. long.

With a short arc the heat is concentrated on the work piece, with



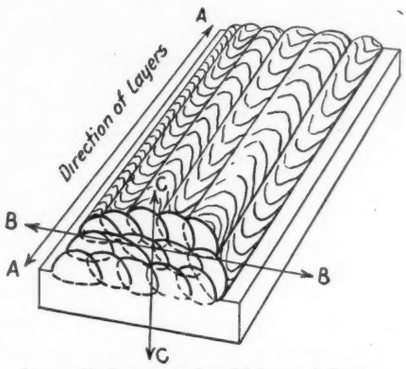
Welding shields like these are used to protect the eyes and face.

The actinic rays given off by the arc will seriously injure the eyes in a short time unless they are protected by the proper glasses. The skin must also be protected in order to avoid burns similar to sunburn. The hand shield (upper left) is ordinarily employed and is held as shown at the right. In some cases, however, both hands are needed for welding and then the helmet type shield (lower left) is used.

the result that effective fusion is secured. In addition there is less chance for the atmosphere to diffuse through the arc stream and form impurities. When a long arc is used it will not maintain its position on the part being welded and the heat from the arc stream and the deposit is greatly reduced by radiation, with the result that the fusion is not complete at the arc terminal formed by the part being welded. Moreover, the formation of impurities and the loss of metal by oxidation are greatly increased, due to the increased exposure of the metal to the atmosphere.

Overhead welding is very difficult or impossible with a long arc, because if the increase in size of the globule of molten metal on the electrode does not bring it in contact with the fused spot on the work it will expand to the point of explosion, or become so large that its weight will cause it to run down the side of the electrode. If the vapor of the arc stream condenses, the arc will be extinguished.

The tendency of the vapor to condense and the ease of maintaining an arc are governed by the stabilizing characteristics of the welding circuit and the arc gases. A high



Deposited metal should be put down in layers and tiers when building up surfaces or filling in joints.

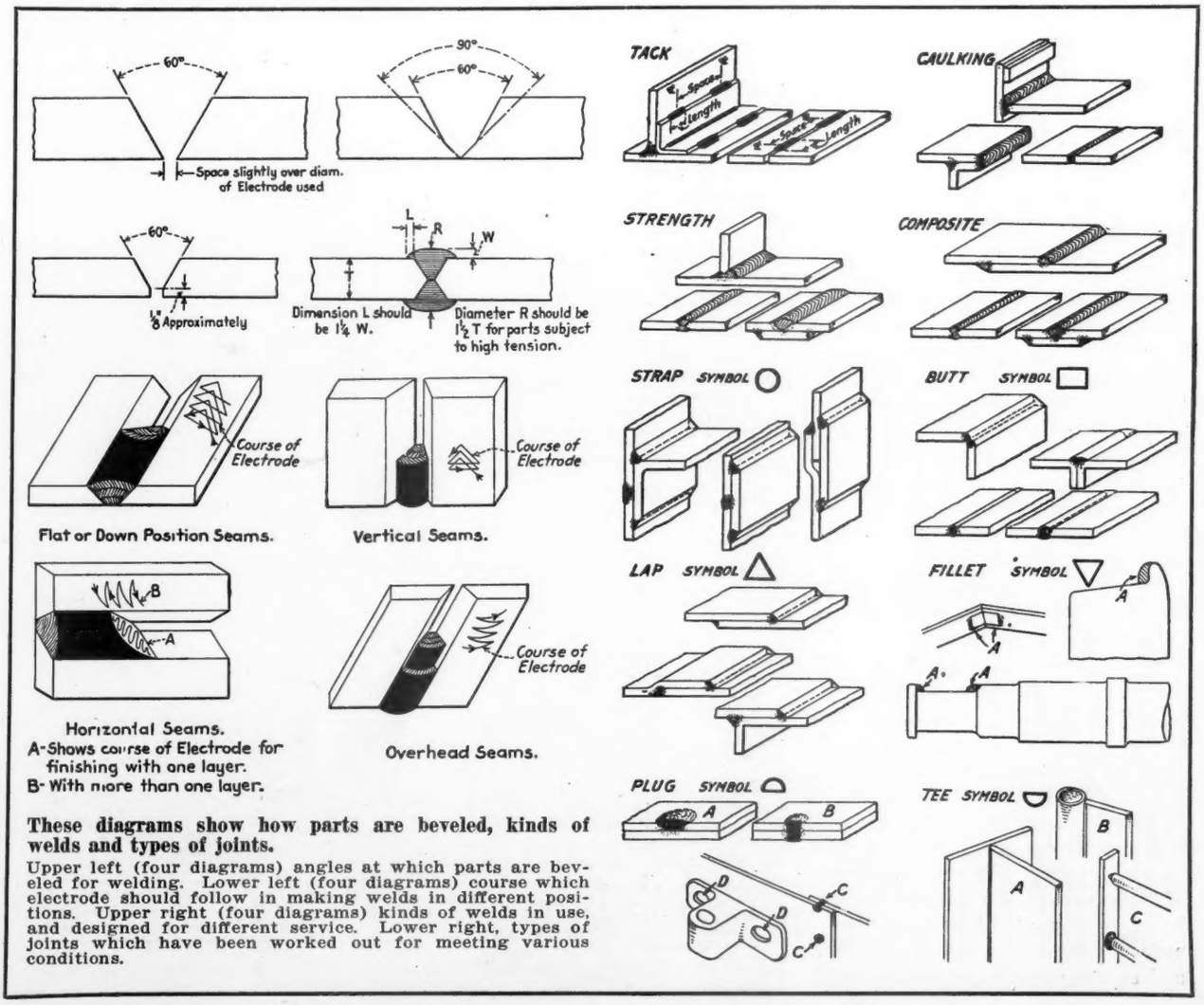
This illustration shows the fusion patterns between adjacent layers. Tests have shown that the best results are obtained when the metal is deposited in the direction of the stress. In this case, maximum strength is along line A-A.

open-circuit voltage or series reactance coils will help to sustain the arc. Any condition which affects the temperature of the arc vapor will affect its stability.

The amount of current required for metallic arc welding is dependent upon so many factors that only approximate values can be given for different sized electrodes. For example, the current required for proper fusion will vary with the type of weld scarf, cleanliness of the surface, heat conductivity of the metal, position of the work, manipulation of arc, and so on. The approximate current and electrode size used in welding mild steel plate of different thicknesses are given below:

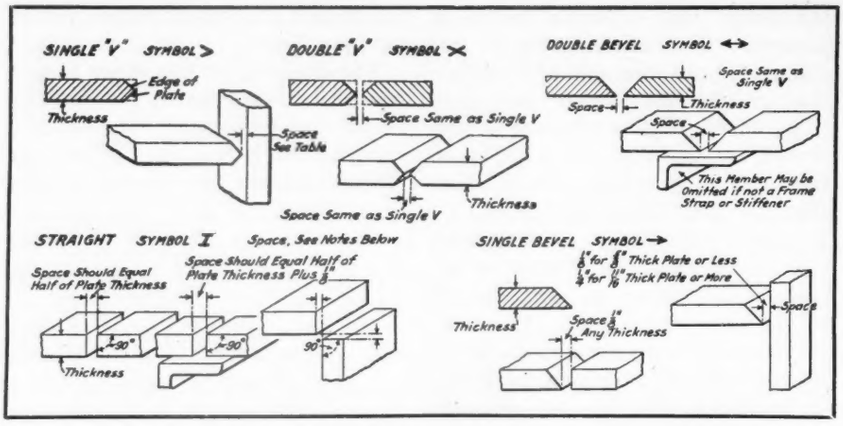
Electrode Diameter, inch	Diameter in mils or thousandths of an inch	Plate thickness, inch	Current in Amperes
3/32	94	1/4 in. and under	50- 90
1/8	125	1/8 in.—1/2 in.	75-150
5/32	156	3/16 in. and up	125-175
3/16	188	3/8 in. and up	140-225

There are a number of conditions which the operator can observe as a guide to indicate when the current



These diagrams show how parts are beveled, kinds of welds and types of joints.

Upper left (four diagrams) angles at which parts are beveled for welding. Lower left (four diagrams) course which electrode should follow in making welds in different positions. Upper right (four diagrams) kinds of welds in use, and designed for different service. Lower right, types of joints which have been worked out for meeting various conditions.



This shows the designs of welds in common use.

The "edge finish," or manner in which the edges of the parts are beveled depends on the nature of the work and the service requirements. The conditions under which the above designs are used is explained in the text.

is correct for proper fusion, such as depth of crater, deposit contour, and uniformity with which the metal comes from the electrode. With the proper current or heat value, the electrode should melt smoothly and the penetration will be sufficient to prevent any of the deposit from overrunning the fused spot on the work. If the current value is too low, however, and a proper arc length is maintained, the metal will not melt smoothly. The penetration will be poor and the deposit contour will indicate overlap of the added metal, due to insufficient fusion of the plate metal.

Parts to Be Welded Should Be Carefully Prepared

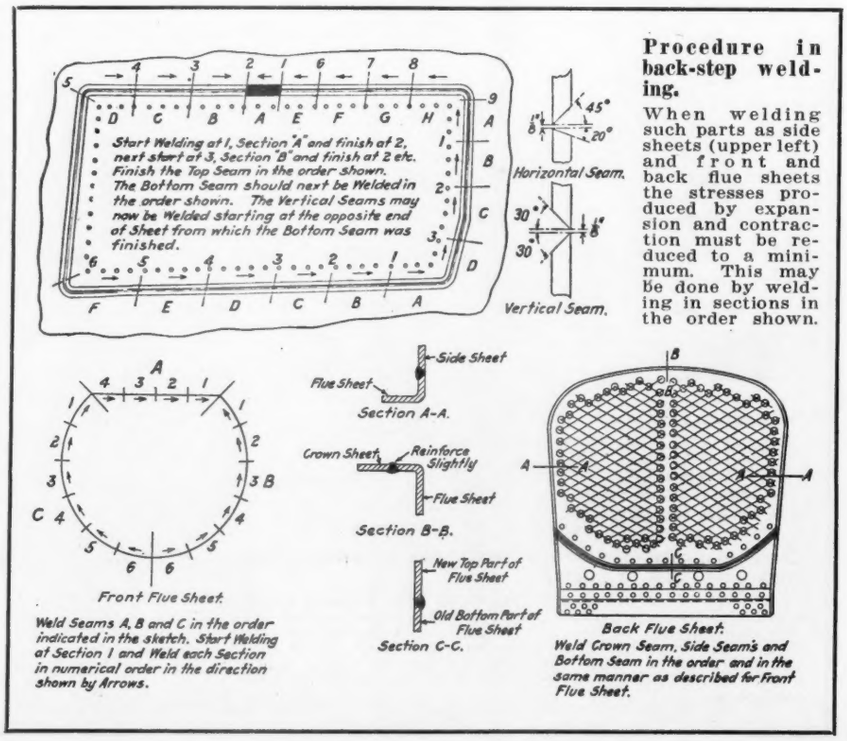
The preparation of the parts for welding is just as important as the welding operation itself and should be given as much consideration. While it is impossible to discuss every case which might be encountered, the general principles outlined here can be applied in most instances.

One of the prime requisites for a good weld is that ample space be allowed, by proper beveling and spacing of the parts, to insure uniform fusion and union throughout the thickness of the welded area. The sole reason, however, for removing metal by beveling plate edges and member ends is to provide this space, and any metal removed unnecessarily is a waste of time and material, as well as a possible source of weakness of the joint. In most cases the metal removed has had mechanical treatment, and this cannot be replaced by autogenous welding with metal of equal quality in every respect, because no metal in a cast form will possess all the characteristics to the same extent as a similar piece which has had mechanical treatment. Excessive space between the edges to be joined is a common cause of defective welds which in service develop fractures. Rewelding a fracture of this kind is exceptionally difficult, and another break will usually occur in a short time. To prevent trouble of this nature, the fitting up and beveling of parts to form seams for welding should be carefully done, and excessive space or unnecessarily wide openings avoided. Then the weld can be made narrow, and by finishing with a slight welt to reinforce and stiffen the joint the neighboring metal will be made to give slightly without bad effect on the weld when tension or transverse stresses are applied.

For plate thickness up to ½ in. a space of ⅛ in. is generally sufficient. The thin edges left by the beveling will be melted down, so that a sufficient opening would be provided, even though the diameter of the electrode is slightly more than the original ⅛ in. space. For sections of greater thickness the space should be equal to or slightly greater than the diameter of the electrode used.

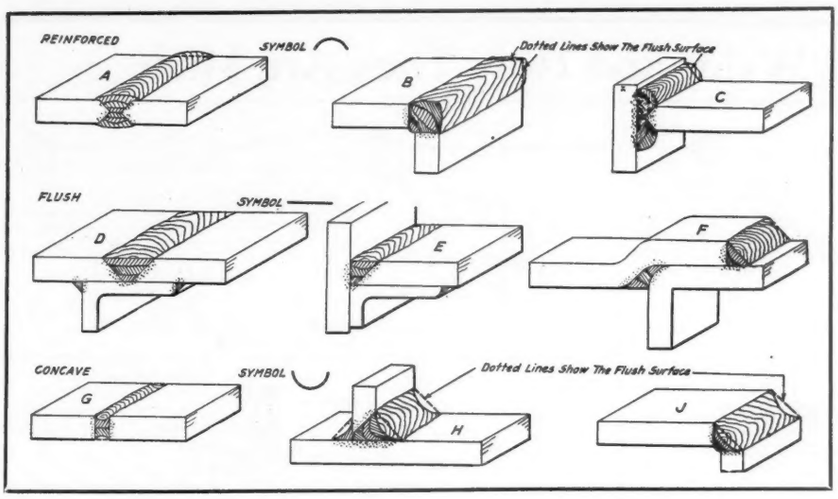
Formerly it was the practice in most cases to provide a total opening of 90 deg. by beveling the edges at an angle of 45 deg. Experience has shown, however, that such large openings are not generally necessary. Usually a total opening of 60 deg. will provide sufficient access to insure fusion along the edges to be joined, and if reasonable care is exercised by the operator, a better weld will be obtained than were a large opening provided. A comparison between a 60-deg. and a 90-deg. angle of opening is shown in an illustration on page 221. A total opening of 90 deg. allows the electrode to be held at right angles to the surface formed by the bevel. As previously stated, the electrode is generally slightly inclined from a right angle to the surface of the work. For this reason an opening of not less than 60 deg. or over 75 deg. will permit the electrode to be held at the proper angle and is sufficient for thicknesses up to at least 2 in.

For parts of greater cross-section the "V" should be cut at the bottom


Start Welding at 1, Section "A" and finish at 2, next start at 3, Section "B" and finish at 2 etc. Finish the Top Seam in the order shown. The Bottom Seam should next be Welded in the order shown. The Vertical Seams may now be Welded starting at the opposite end of Sheet from which the Bottom Seam was finished.
45°
20°
Horizontal Seam.
30°
30°
Vertical Seam.
Front Flue Sheet.
Weld Seams A, B and C in the order indicated in the sketch. Start Welding at Section 1 and Weld each Section in numerical order in the direction shown by Arrows.
Side Sheet
Flue Sheet
Section A-A.
Crown Sheet
Reinforce Slightly
Flue Sheet
Section B-B.
New Top Part of Flue Sheet
Old Bottom Part of Flue Sheet
Section C-C.
Back Flue Sheet.
Weld Crown Seam, Side Seams and Bottom Seam in the order and in the same manner as described for Front Flue Sheet.

Procedure in back-step welding.

When welding such parts as side sheets (upper left) and front and back flue sheets the stresses produced by expansion and contraction must be reduced to a minimum. This may be done by welding in sections in the order shown.



These are the different types of welds designed to meet various purposes and conditions of service.

A reinforced weld is used for obtaining maximum strength by building the welding up above the surrounding plane. The flush type is used when the welded surface must be level with the adjacent metal. It possesses less strength than the reinforced weld. A concave weld is the weakest of all and is used for filling in or caulking, where strength is not important.

to form a 90-deg. angle for a distance of not more than half the depth of the "V," this angle being reduced to approximately 60 deg. as the outer surface is approached. This method of beveling should be used when the character of the work does not permit separation of the edges. In case of unavoidably large openings between edges, a scarf angle of 60 deg. along the entire length is sufficient. While the angle of opening should be as small as is consistent with good welding, it is absolutely necessary that sufficient space be provided to allow access for fusion between the deposited metal and the beveled edge to be joined.

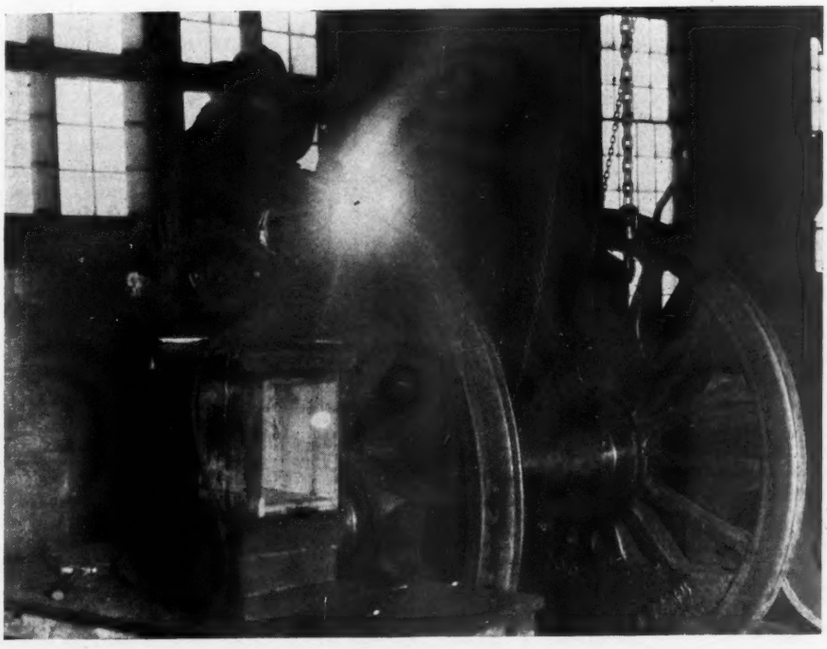
For a sheet thickness of approximately ⅛ in. when a ⅛-in. opening is provided, the edges may be left in their crude or sheared state. Sheets less than ⅛ in. in thickness are prepared with straight edges and no space is left between, since the penetration of the arc will be sufficient to effect fusion through the reverse side. When welding exceptionally thin sheet metal, a copper plate is sometimes placed on the reverse side of the seam to serve as a backing for the metal and to increase the conductivity, so that the thin edges will not be melted away. Thin sheets are often welded by forming a seam with flanged or upturned edges, and melting them together with a graphite or carbon electrode. The addition of metal is not necessary, as the melting down of the thin edges provides sufficient reinforcement at the weld section.

Allowance Must Be Made for the Contraction of the Welding Material

The contraction of the deposited metal constitutes one source of trouble in metallic arc welding, and is responsible for most of the locked-in stresses in welds and the distortion of the parts welded. While expansion and contraction cannot be prevented, their effect can be minimized by certain methods of arranging the parts preparatory to welding, or by the manner in which the deposited metal is applied.

For example, when welding long butt seams of medium thickness the plates tend to buckle in at the weld. Due to the beveling, the deposited metal is wider at the top of the weld than it is at the bottom; consequently the contraction is greater. In addition the contraction of the weld will draw the edges of the plates together and thus throw the latter out of line. When other conditions permit, this tendency may be overcome by allowing a little wider space between the plates at the opposite end from which the weld is started. The exact amount to be allowed in this way depends on several factors and must be learned by experience. Clamping the parts down or tack-welding so as to make the metal give slightly on cooling is frequently done in the case of heavy sections, but is not always to be recommended for light material.

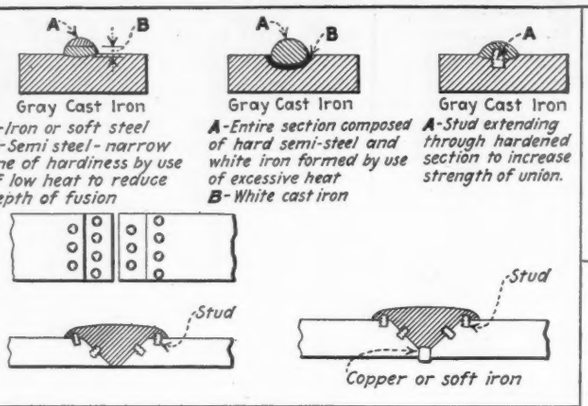
A sequence of welding, designed to distribute the heat and contraction stresses more evenly throughout the joint, is known as the "backstep" method. The parts are tack-welded at intervals of six inches or less for short seams. The arc is then applied at the second tack and the groove welded back complete to the first tack. Going to the third tack, the

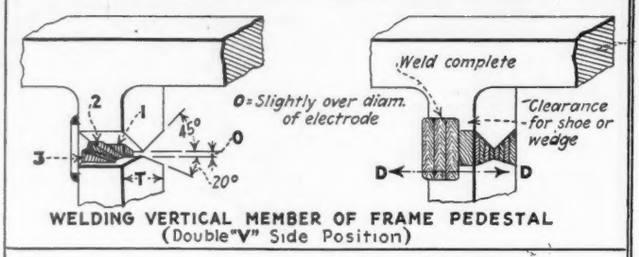


Arc welding is prolonging the life of these driving wheel tires.

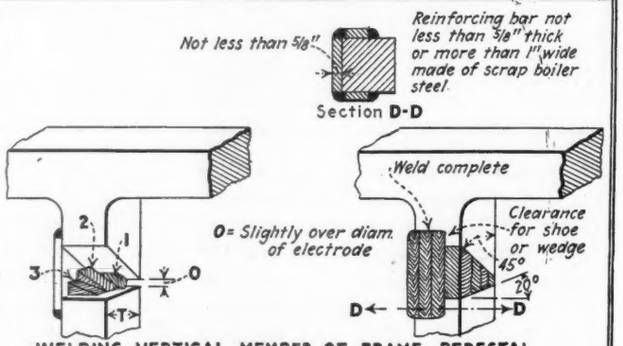
Although the flanges have worn too thin, some electrodes and a few hours' time of an electric welder will put these driving wheels on the road again. Without some means of building up to the proper thickness it would be necessary to remove the old tire and shrink on a new one. When welding high-carbon steel material, such as driving wheel tires, it is advisable to preheat the metal ahead of the welding arc in order to prolong the rate of cooling and minimize the effects of the welding operation on the base metal.

Some Typical Welds and How They Are Made

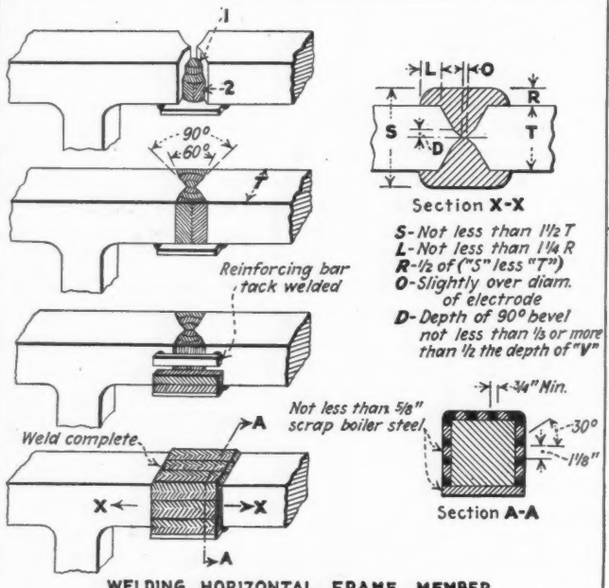

A
B
Gray Cast Iron
A-Iron or soft steel
B-Semi steel - narrow line of hardiness by use of low heat to reduce depth of fusion
Gray Cast Iron
A-Entire section composed of hard semi-steel and white iron formed by use of excessive heat
B-White cast iron
Gray Cast Iron
A-Stud extending through hardened section to increase strength of union.
Stud
Stud
Copper or soft iron



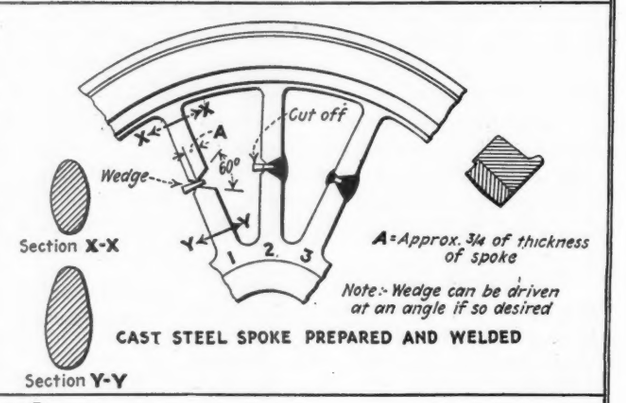
WELDING VERTICAL MEMBER OF FRAME PEDESTAL
(Double "V" Side Position)



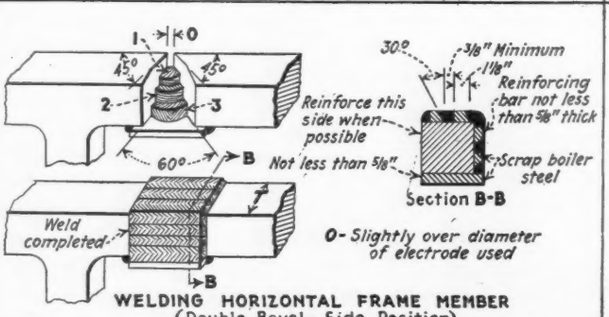
WELDING VERTICAL MEMBER OF FRAME PEDESTAL
(Double Bevel - Side Position)



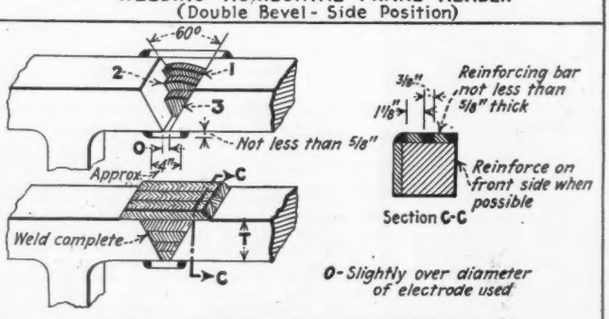
WELDING HORIZONTAL FRAME MEMBER
(Double "V" - Side Position)



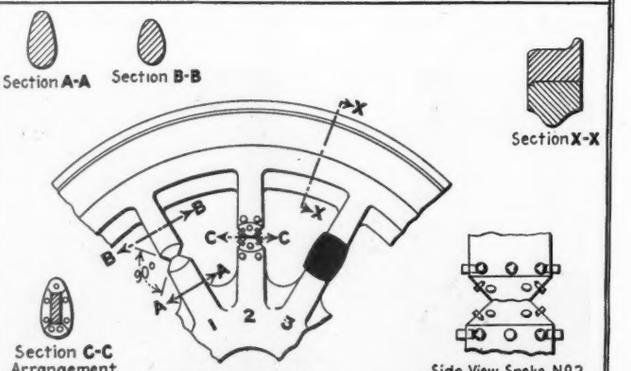
CAST STEEL SPOKE PREPARED AND WELDED



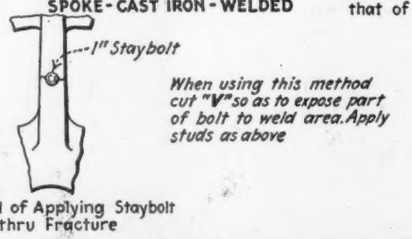
WELDING HORIZONTAL FRAME MEMBER
(Double Bevel - Side Position)

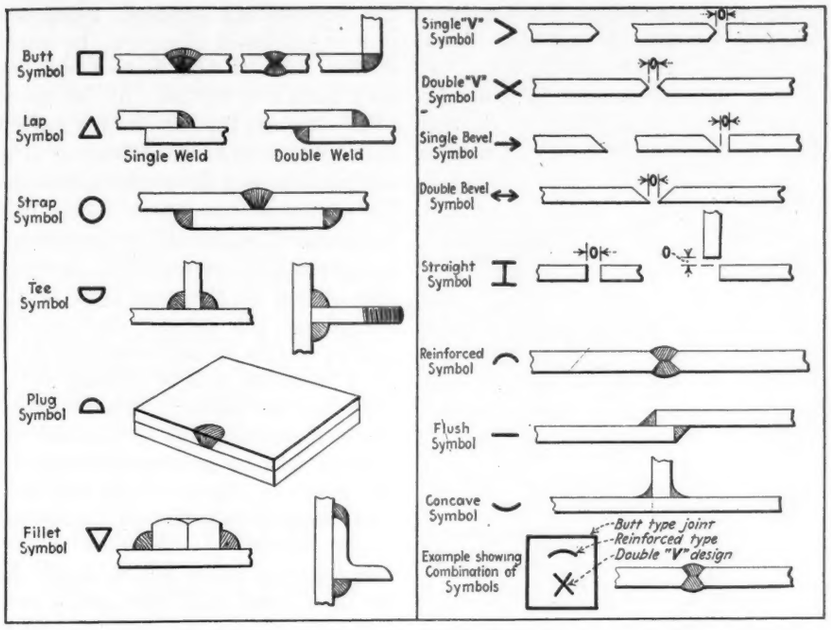


WELDING HORIZONTAL FRAME MEMBER
(Double Bevel - Flat Position)



SPOKE - CAST IRON - WELDED


1" Staybolt
When using this method cut "V" so as to expose part of bolt to weld area. Apply studs as above
Method of Applying Staybolt thru Fracture



Symbols used to designate types of welds and joints.

weld is carried back to the second tack, practically completing that section. Each section should be finished at least flush before starting another.

For Convenience in Specifying, Joints and Welds Are Divided into Several Classes

In order that the engineer or designer and the welding operator may have a mutual understanding of what is required in a given job, welds are specified under the terms "Type of Joint," "Design of Weld," "Position of Weld," "Kind of Weld," and "Type of Weld."

The various types of joints and designs of welds that are used are shown in the illustrations on this page, under the recognized standard names or terms used to designate them, together with their symbols.

Butt Joint.—This is generally used when it is desired that the parts welded form a flat plane or smooth surface, except for the possible projection formed by the slight reinforcement of the weld proper. The double "V" design of weld is preferable to other methods of preparing parts for butt welding, and when conditions permit, this design should be used.

Lap Joint.—This is used in cases where the placing of one edge above the other is not objectionable. In arc welding a lap seam is less difficult to weld than a butt seam and when the edges of each plate can be welded to the surface of the other, so as to form a double weld, the joint is generally considered to be more efficient than a butt weld. The conditions under which the welding is done and the service requirements of the joint will determine the choice between the butt and lap type of joint. Both are in successful commercial use, and in many cases both are in service of the same nature.

Strap Type of Joint.—This is used when the welding can be performed from both sides. It is employed for work where maximum strains are to be sustained. In this type the seam can be welded only from the side of the work opposite the reinforcement and this must be welded to the side of the work to which it is applied. The exceptional strength is attained by the mode of applying the welding material, and through the sectional area per square inch exceeding that of the surrounding material. In railroad work the strap type of joint is used for such important welding applications as truck side frames and bolsters and other parts where a failure in service would jeopardize life and property.

Tee Type of Joint.—When one plate is welded perpendicularly to another this joint is used, or when a rod is welded in a vertical position to a flat surface.

Fillet Weld.—When a fixture or member is attached to the face of a plate by welding along the vertical edge of the member, this form of weld is used. This term is also applied when metal is added in a corner.

Plug Weld.—As the name indicates, this weld is employed to connect two parts by welding through a hole in one of them. It is also used for filling through a bolt or other hole.

"Design of Weld."—This term refers to the edge-finish of the parts to be welded. Single "V" signifies that the edge of the part is beveled from both sides to an angle. This design is used when the part is vertical to the face of the adjoining member, when maximum strength is required, and only when welding can be done from both sides.

Double "V" Weld.—This means that the adjoining edges of plates are beveled from both sides to an angle. It is used when two plates are to be butted together for a maximum strength weld, and can be used only when the electrode can be applied from both sides.

Straight Weld.—This term indicates that the plate is left just as sheared. With thick plates it should be used with a strap, stiffener or frame, or else when maximum strength is not essential. It may be used for a strength weld with plates not over 3/16 in. thick, or when the edges of two plates are at right angles to each other.

Single Bevel.—This is a term signifying that the edge of a plate is beveled from one side only to an angle. This design is used for strength welding when welding can be done from one side only, or when it is not possible to finish the adjoining surface.

Double Bevel.—This means that the adjoining edges of both plates are beveled from one side only to an angle. It is used when maximum strength is needed and where welding can be done from one side only.

Under "Position of Weld" the term *flat* signifies that the welding material is applied on the same plane as the floor, allowing the electrode to be held in an upright position.

Horizontal indicates that the welding material is applied to a seam or opening whose plane is vertical to the floor with the line of the weld parallel to the floor.

The *vertical position* means that the welding material is applied to a surface or seam which is upright or vertical to the floor.

The *overhead position* is determined when the welding material is applied from the underside of any parts whose plane is parallel to the floor, and thus necessitates the electrode being held in a downright or inverted position.

The Designation "Kind of Weld" Refers to the Service Requirements.

A caulking weld is one in which the density of the crystalline metal closing a seam or opening must be such as to allow no visible leakage under a water, oil or air pressure of 25 lb. per square inch.

A strength weld requires that the sectional area of the welding material be such that its tensile strength and elongation per square inch must equal at least 80 per cent of the ultimate strength per square inch of the surrounding material.

In a *composite weld* the strength must meet the requirements specified for a strength weld, while the density must equal that of a caulking weld.

A tack weld consists in welding in small sections or spots, for holding two edges together or for temporarily holding in place parts that are to be solidly welded.

Several different "Types of Welds" are in use. The *reinforced weld* indicates that the deposited metal is built up above the plane of the surrounding material. This type of weld is used to obtain the maximum strength.

The *flush weld* signifies that the welding material is finished level with the

surrounding parts, or at an angle of 45 deg. when it is used to connect two surfaces at an angle to each other. Inasmuch as less metal is applied, the strength is less than that of the reinforced type.

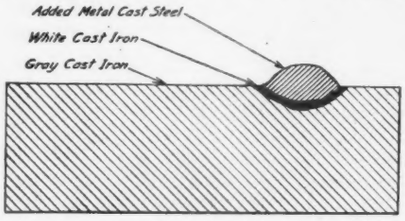
A *concave weld* is one in which the deposited metal is finished below the level of the surrounding material or, in case of an angular connection, beneath a 45-deg. plane. This type of weld is weaker than either of the foregoing and is used for filling in seams, caulking, and so on.

Cleaning the Metal to Be Welded Is Important

Welding must always be done on clean metal, as the presence of oxide, dirt or grease interferes seriously with the process. Parts which have a coating of heavy grease should be cleaned by washing with gasoline or boiling in a lye solution. Surfaces covered with paint must also be thoroughly cleaned before welding. Two wire brushes, one a casting brush with long, coarse wires and the other a painter's wire brush about 1¼ in. wide and with rather fine wires, are useful in removing red oxide and dirt which is not greasy. Mill scale or the oxide left from the oxy-acetylene torch, or scale formed on top of the weld, cannot easily be removed by a wire brush. Scale may be loosened by a roughing tool in the form of a chisel, and removed by a wire brush, but sand blasting is preferable. Sandblasting is a rapid and easy means of obtaining a clean surface and if much welding is done a suitable outfit should be secured.

The cleaning should extend over a considerable area in the vicinity of the fracture to be welded, in order to expose any flaws or defects, such as gas pockets, shrinkage cracks, and so on, that may exist. Such defects often go unnoticed and later form the basis of another failure.

Slag inclusions are a common source of weakness in all welds, and can be eliminated only by keeping the work perfectly clean as the welding progresses. Dirt or scale on the surface will cause the arc to shift and become erratic, resulting in undue exposure of the arc stream to the atmosphere, with an attendant increase in brittleness. The scale or slag formed on top of the deposited metal should therefore always be removed before adding one layer to another.



A weld in cast iron contains three kinds of metal.

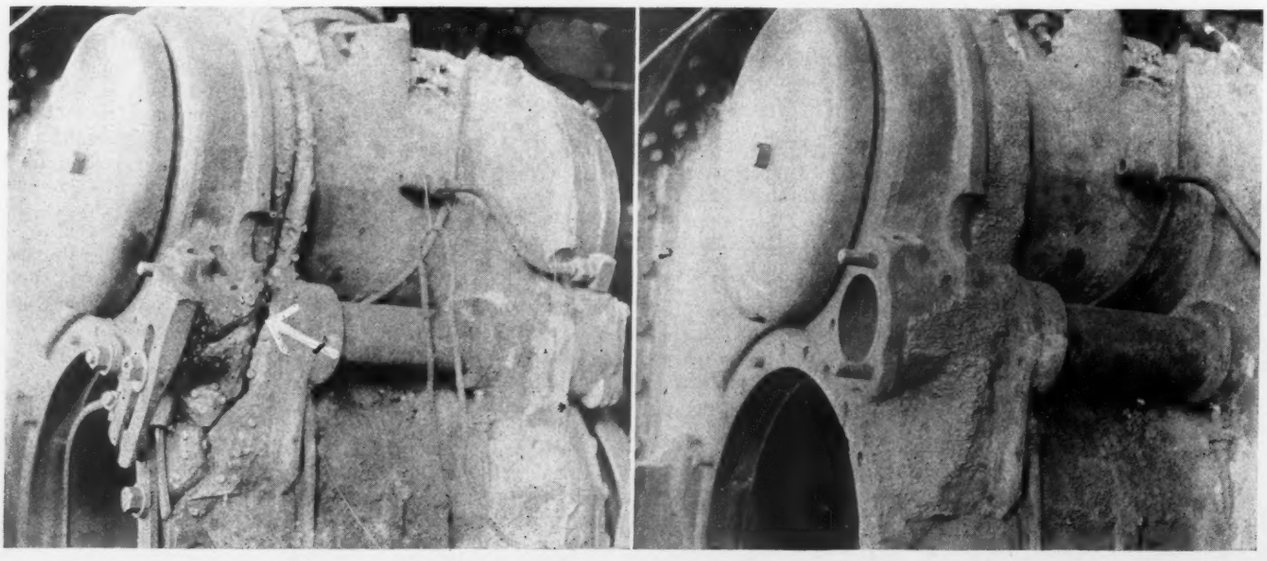
The molten cast iron combines with a portion of the carbon originally present as graphite, and on chilling rapidly forms hard and brittle white cast iron. The first layer of the deposited metal also takes up enough carbon to make it very hard, on rapid cooling. The remainder of the deposit is much softer.

Welding Procedure Varies With the Character of the Metal

Welding Cast Iron.—When metal is fused to a piece of cast iron by the arc-welding process, using an iron or mild steel electrode, the metal at the base of the deposit will be very hard and brittle. At the point of arc contact the cast iron is melted and iron or steel is deposited into the molten spot from the electrode. The metal at the line of union and immediately adjacent thereto is what may be called "semi-steel." Some of the carbon of the cast iron is absorbed by the deposit and as the melted metals usually cool quickly, a hard structure will be formed at the base of the deposit. The distance the hardness extends up through the deposit will be governed largely by the depth of fusion of the cast iron and the chilling action of the section being welded. If the cast iron is melted only for a slight depth, by using a small electrode and a very low heat value, the amount of carbon absorbed by the deposit will be small, so that in many cases the surface of the deposit will not be appreciably hard. There will, however, be a hard line at the point of union if the cast iron is actually fused.

If an excessive heat value is used, not only will the deposit be hard throughout, but the adjacent molten cast iron will combine with the carbon and on cooling quickly will form white cast iron. From this it will be seen that a heat value as low as is consistent with good work should be used for cast iron welding by the metallic arc process.

During welding, the impurities in the cast iron and those formed by welding tend to rise to the surface of the deposit, and may be trapped in the first layer, on rapid cooling. Quick cooling may cause checks in the hardened (*Continued on page* 258)



Crack in a locomotive cylinder prepared for welding by the insertion of wrought iron studs.

When welding cast iron parts, it is the usual practice to insert a number of wrought iron studs along the line of the break, in addition to V-ing out the edges. These studs facilitate the deposition of the metal and make a much stronger and more serviceable weld.

WHERE SPEED of production is an important consideration, as it is in most plants, convenience and reliability in the operation of the electrical equipment are equally important points. Motors and other apparatus may be located out of the way of machine operators. But the control must be always under the operator's thumb, so to speak. At the same time motors must be protected so that the overzealous operator cannot force them beyond their overload rating.

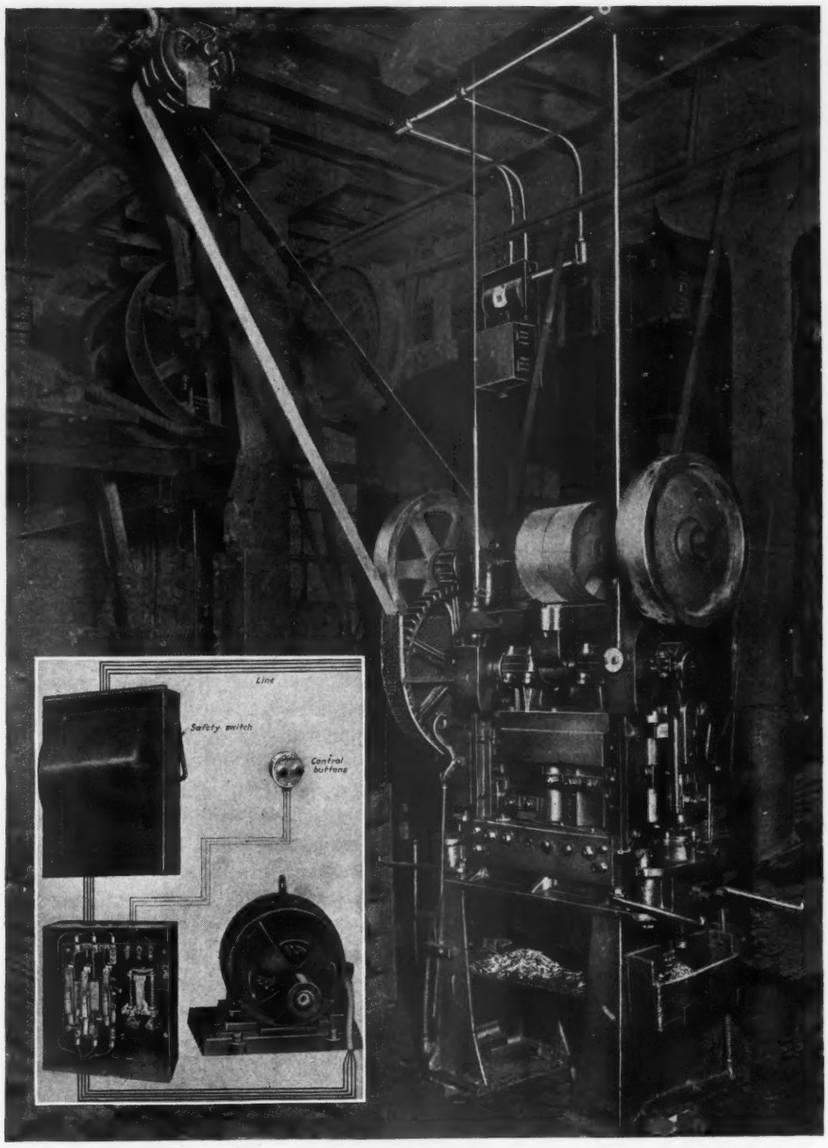
Here Is a Plant Where Handy and

Protected Motor Service

Has Speeded Up Machine Production

By T. W. C. HARTMANN

Engineer, Keystone Spring Works, Philadelphia, Pa.



A trimming press in the plant of the Keystone Spring Works, Philadelphia, Pa., is shown here driven by a 3-hp. induction motor. The features of control and protection are illustrated in the inserted diagram.

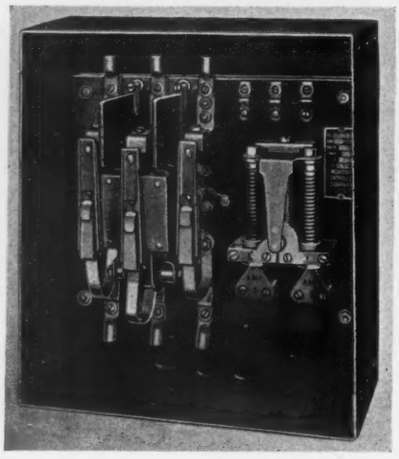
IN a recent installation at the Keystone Spring Works, Philadelphia, Pa., protection for motors and convenience in operation have been combined in a practical manner. In this plant all machines are driven by individual motors, usually mounted overhead. They are controlled at the machine by push buttons which operate magnetically closed circuit breakers, also mounted at the ceiling, with protection afforded by relays. The entire installation is enclosed in steel conduit or boxes.

It was in January of this year that this company completed its change-over from steam to electric drive. The installation of individual motors for each machine was done during the course of three months without an interruption to production. This work was done under the direction of Arthur H. Allen.

The company makes springs for various kinds of motor-driven and horse-drawn vehicles. This work requires such machines as rollers, drop hammers, eye machines, slot and nibbers, shears, punch and trimming presses, grinders and drill presses. A number of these machines, like the rollers and presses, have heavy flywheels. The inertia of these flywheels combined with the abnormally high room temperature caused by hot gases from furnaces and forges, makes starting and operating conditions on many of the motors unusually severe.

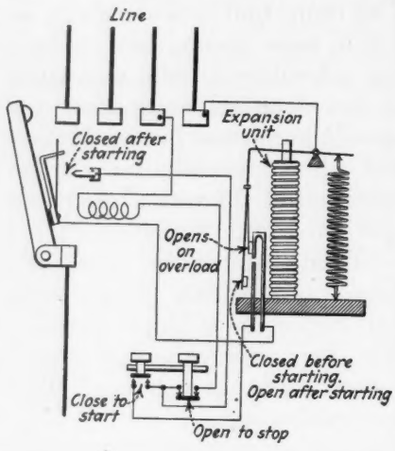
Thirty Triumph motors ranging in size from 1 hp. to 5 hp. were installed for the machines and operate on a 220-volt, 60-cycle, 2-phase, 4-wire distribution system. The motors are mounted on the ceiling beams and belt-connected to the machines. The circuit of each motor passes through a Square D safety switch located above the machine on the ceiling beams. These switches are bolted to two strap-iron pieces which are screwed to the sides of the joists or beams.

On the same strap-iron supports immediately below the safety switches are bolted Monitor "thermaload" starters. Each starter is enclosed in a steel box. It consists of a small air-break circuit breaker and thermal-limit relays that provide low-voltage, overload and single-phasing protection and operate as described in the following paragraphs.



Remote-controlled starter used for throwing small alternating-current motors on the line.

A view of the inside of the starter box is shown at the left and at the right a schematic diagram of the starter and connections. When the button to the left in the diagram is pressed the solenoid pulls the breaker to the closed position. Normally it remains in this condition until the button to the right is pressed. It will open, however, under the following conditions: (1) Overload of sufficient magnitude and duration to damage the motor; (2) low voltage, and (3) failure of one phase when the motor is carrying such a load as to cause damage to the windings on phase failure. A general idea of the connections can be obtained by observing the small diagram inserted in the large illustration at the beginning of this article.

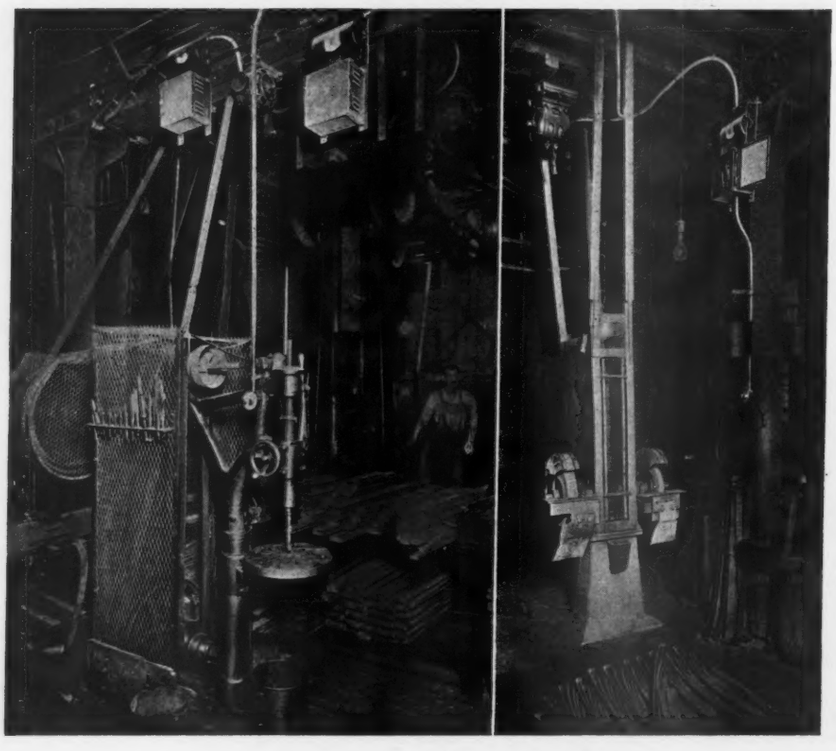


Running through conduits down to the driven machine is the control wiring, and mounted on the machine is the control station, consisting of start and stop push buttons. This station is small and can be placed in accessible locations without interfering with the work on the machine. The accompanying photographs show that these little stations are very close to the operator's hand.

These starters connect the motor directly to the line. As the diagram above shows, when the starting button is pressed, the solenoid is energized and this closes the circuit breaker. Only momentary pressure of the button is needed as an auxiliary contact made upon closure of the breakers maintains the circuit through the solenoid. To shut down the motor, the "stop" button is pressed. This opens the solenoid circuit, thus releasing and opening the breaker.

On overload the relays open the solenoid circuit and thus shut down the motor. The relays depend for action on the expansion of a corrugated metal tube. This is a closed, double-walled tube with the space between the walls filled with a non-corrosive and non-freezing liquid. Inside the tube is a thermal element consisting of a coil of wire through which the motor current passes. Excessive current heats this wire and the heat absorbed by the tube causes it to expand. When the tube expands to a certain length it opens the circuit to the solenoid, thus opening the breaker. Whenever the breaker is open it can be closed only by pressing the control button. An interesting feature of such protection is that momentary overloads which will not damage the motor do not raise the temperature of the expansion unit sufficiently to open the circuit. Furthermore, motor and starter are located near each other, so that local temperature conditions affect both. Low voltage will cause the holding solenoid to release the contactor and open the circuit. Failure of one phase will trip the relay provided the current drawn by the motor is sufficient to damage the motor.

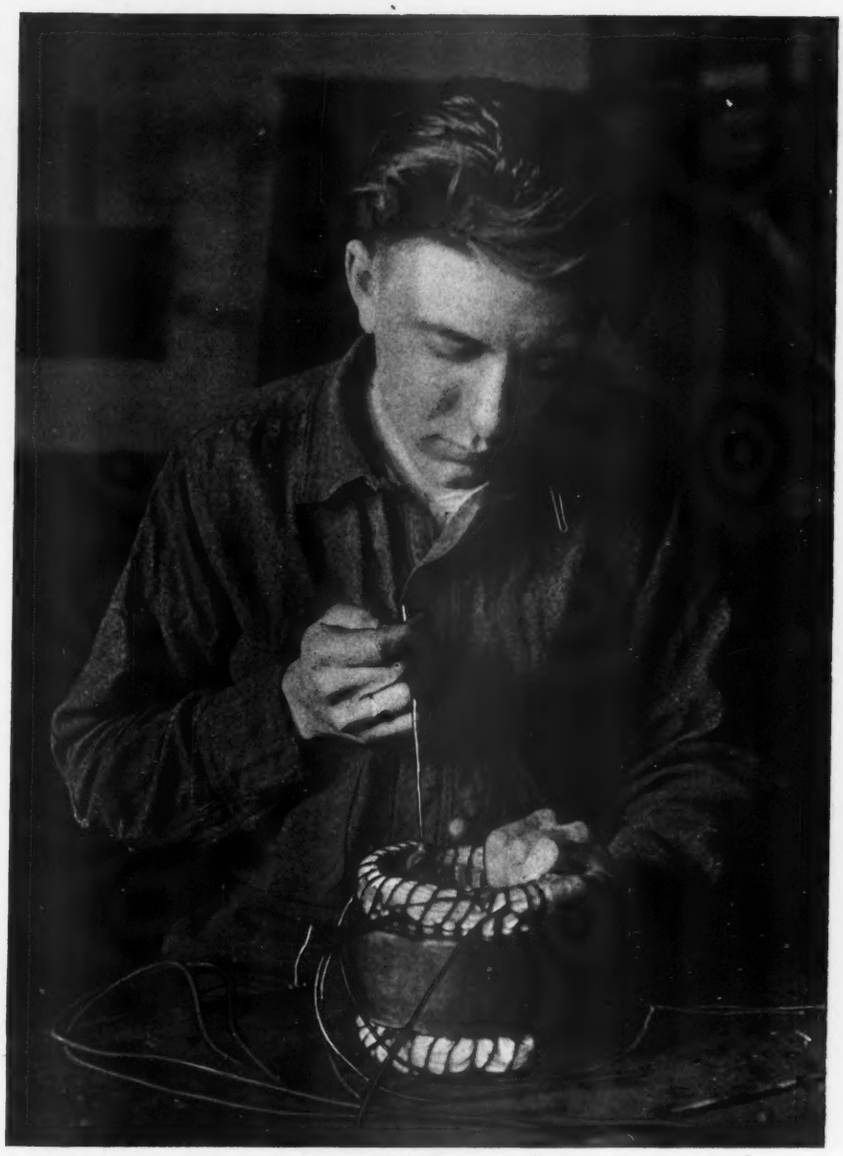
The same type of controller is used by all motors. The thermal elements of the relays are interchangeable, all being of the same construction with the exception of their current-carrying wire which determines the rating. The thermal elements are made of large-size low resistance wire. Each unit is wound for a particular rating and the resistance is so chosen that the watt consumption at full load will be approximately 2.14 watts. Therefore a given relay can be used for any rating by inserting the proper thermal element. To prevent unauthorized tampering, the boxes may be locked if desired. (*Continued on page* 257)



These two installations show how convenient push-button control can be made while the switches are entirely out of the way near the ceiling.

At the left the push buttons are located on the machine frame almost touching the hand which feeds the drill. A squirrel-cage 1-hp. 2-phase 60-cycle motor drives the drill. The starters and safety switches for this motor and others can be seen mounted on strap-iron supports hung from the ceiling beams.

THE METHODS outlined in this article can be followed for rewinding stators of small single-phase motors, including the repulsion-starting type. The suggestions on inspection before stripping are important and will not only locate troubles and faults but save much time. The directions for taking data from the old motor, stripping the winding, insulating the slots, making a skein and winding it in place, putting on a hand winding, connecting the windings and testing the completed job, are the result of much experience in rewinding work. Mr. Roe is shop superintendent of the Detroit Service Department of the Westinghouse Electric & Manufacturing Company.



Step-by-Step Procedure for

Winding Split-Phase Motors

And Locating Troubles Explained by A. C. Roe

BEFORE STARTING to disassemble a small alternating current motor that comes into a shop for repairs, it should be given a thorough general inspection. This inspection will locate most mechanical faults and electrical troubles such as an oily switch, bent switch parts, worn bearings, starting or running windings burned out or water-soaked coils. These troubles are easily found, but sometimes a motor which is apparently in good condition may not operate properly.

When a motor has been found in good condition after a general inspection, it should be tested with twice normal voltage (alternating current) from ground to the windings. If the windings hold up under this test and the trouble does not show up, it must be located in other ways. If the bearings are o. k. and the windings and connections are good, but the motor will not start, bring the motor up to speed and throw it on the line. The motor may be brought up to speed by winding a length of tape around the shaft and then giving it a quick pull. After the motor has been started in this manner and thrown upon the line and it operates without heating or unusual noises, the running winding is in good shape, but the failure to start is probably due to an open circuit in the starting winding. To find this, remove the end bells and the rotor. Check each section of the winding with a test lamp from the leads to the switch, switch to the coils and across each coil until the open circuit is located.

If the motor will not start after being rotated by the tape method, but tends to jam and hum, there is probably a short circuit in the running coils. In such a case, remove the end bells and rotor and connect the running winding across the line. Place the blade of a screwdriver against the iron in the center of each coil and pull it up away from the iron to test the magnetic strength of each coil. The coil which has the least pull is the short circuited one. A small growler, such as used for testing larger motors, may be made for testing the stators of small motors. In making this test, do not leave the current on the windings too long or they will burn out.

If the windings seem in good condition but the motor will not pull its load, inspect the rotor to see if all the bars are making good contact. If poor contacts are found, resolder the rotor. Sometimes a motor will start but will not come to speed on account of the fact that the

springs on the switch are too light and fly out before the rotor reaches the running speed.

If the trouble cannot be determined by any of these methods, it may be well to read further into this article to learn how the windings are put on and connected. An understanding of the windings will often help the repair man to know just what the trouble is.

Taking the Data From the Motor Before Stripping

When it is known that the motor has to be rewound, the first thing to do is to take the winding and nameplate data. A very good plan is to use individual 3-in. by 5-in. cards for each motor, such as shown in A, Fig. 1. First take the nameplate data of the motor, putting down the horsepower, voltage, cycles, speed, serial and style numbers, etc. After this data is recorded, then put down details of the kind of connection, the number of coils, etc., as shown on the card in Fig. 1. The method of getting all this information is described in the following paragraph. After the cards are filled out they should be filed in alphabetical order according to the customer's name, for working reference. When the rewinding job is completed, the card should be filed according to make, such as Westinghouse, General Electric, Robbins & Myers, etc. Under each make they should be sorted into types, such as *CA, AR,* etc., and finally subdivided according to horsepower. When a file of this kind has been built up it can be consulted whenever a motor is brought into the shop for rewinding and if the motor is identical with one which has been wound before, the former information may be followed without going to the trouble of getting the information again from the motor received.

Fig. 1—Data like this should be recorded before a small single-phase motor is stripped.

A convenient way to record such data is to use 3-in. by 5-in. cards as shown. At *A* is the face and at the right the back of the card. The back is filled in to indicate the number of times the skein is placed in the different slots of a skein-wound stator. The same winding is indicated at *B* and *C* which show the back of a card filled in by two different methods. The top illustration at right of *A* shows a more complete method which contains the same information as shown in *C*. The figures indicate the number of turns in the slot. For a beginner it may be better to follow the method shown at the right of *A* as this indicates more clearly the number of turns in each slot. At *D* are data for a two-pole motor. At *E* is information taken from a skein-wound four-pole motor in which the coils do not overlap.

How to Get Information on Winding and Connecting from an Old Motor

After the nameplate data has been put down, the number of slots, the bore and length of the stator iron should be recorded and the connections should be checked, whether series or parallel, etc. Then to make the stator easy to strip and to take data from, connect it across full line voltage and allow current to flow through the windings (both running and starting) until they smoke and become hot. This will loosen all the varnish, oil, etc., and allow the wires to be pulled apart. The information on the starting windings should be taken first because they are usually on top. Most starting windings are skein wound. In getting the information, lift up the end starting coil so that you can see how many slots are skipped from one side of the coil to the other and the number of times the skein is put through each slot.

Customer K. C. Master + Co. Order No. 2326
Make Hp. 1/3 Volts 110 Cycles 60
Serial No. 56699 Style No. F-5 Type S T R.p.m. 1725
No. Slots 36 No. Poles 4
Running Coils: No. 4 Connection Parallel
Turns 30-1 No. 20 S.C.+En. In. per turn 59 Total Lb. 2
Starting Coils: No. 4 Connection Parallel
Turns 57-1 No. 30 S.C.+En. In. per turn 32 Total Lb. 1/4
A Wanted 5-1-22 Issued 4-5-22 Completed 4-29-22
SLOT NO. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
RUNNING WINDING 30/ 60 60 30 • • 30 60 60 30/30 60 60 30 • • 30 60 60 30/30
STARTING WINDING 114 57 • • • • 57 114
For hand winding back of card may be filled like this or as shown below
RUN 1/1 2 2 1 0 0 2 2 1/1
START 2 1 X X X X X 1 2
Back of card filled like this for skein winding
B
RUN 30/30 60 60 30 0 0 30 60 60 30/30
START 114 57 X X X X X 57 114
C
Customer Order No.
Make Hp. 1/4 Volts 110 Cycles 25
Serial No. Style No. Type R.p.m. 1440
No. Slots 24 No. Poles 2
Running Coils: No. 2 Connection Parallel
Turns 42-1 No. 20 S.C.+En. In. per turn 20 Total Lb. 2 3/4
Starting Coils: No. 2 Connection Parallel
Turns 42-1 No. 25 S.C.+En. In. per turn 11 Total Lb. 1/2
Wanted Issued Completed
Customer Order No.
Make Hp. 1/6 Volts 220 Cycles 60
Serial No. Style No. Type R.p.m. 1720
No. Slots 36 No. Poles 4
Running Coils: No. 4 Connection Series
Turns 37-1 No. 20 S.C.+En. In. per turn 65 Total Lb. 3
Starting Coils: No. 4 Connection
Turns No. In. per turn Total Lb.
Wanted Issued Completed
Run 1/1 2 2 2 1 0 0 0 1 2 2 2 1/1
D Start 1/1 2 2 2 1 0 0 0 1 2 2 2 1/1
C D A
Run 2 2 1 0 0 1 2 2 0 2 2 1 0
E Start 2 2 0 0 0 4

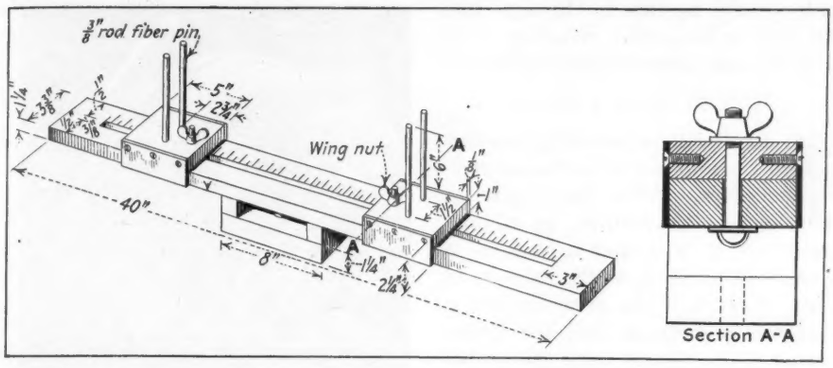


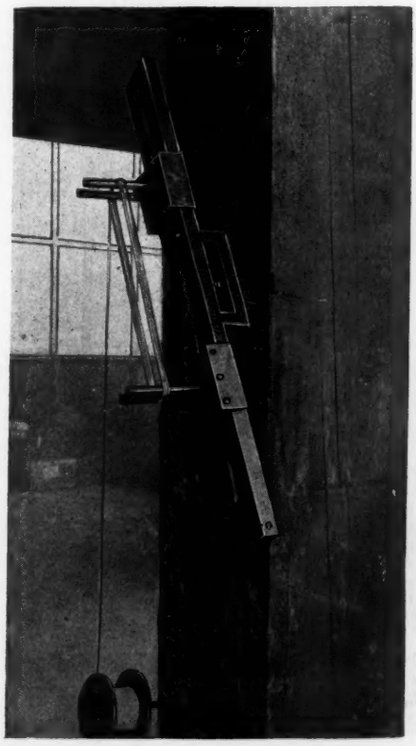
Fig. 2—Details of an adjustable shuttle on which skeins are wound. Fig. 3—Shows the shuttle in operation.

In *A* of Fig. 1 the starting winding skipped five slots as indicated by the dots and slots 7 and 13 each contain one side of the skein. In slots 6 and 14 the skein is put through twice. The starting coils do not overlap each other.

It is very important before removing the winding of a repulsion type of motor to mark the slots in which a pole group starts. The motor must be rewound so that the general line of the pole will be in the same position in reference to the brush as it is in the original winding.

The data for the main or running winding is next recorded. This may be either a hand or skein winding. It is easy to determine which it is by inspection. The skein winding will show the ends crossing each other whereas the hand-wound coil will have a neat uniform appearance. The data in *A* of Fig. 1 shows that in the main winding, the slots 4 and 7 have thirty turns. Slots 2, 3, 8 and 9 have sixty turns, showing that two turns of the skein were in these slots. The dividing line in slots 1 and 10 indicates that the coils overlap. The data also show the position of the running winding in reference to the starting winding. All of this information should be put down on the card. The drawings in *B* and *C* of Fig. 1, show the winding data put down in a more simple manner. This may be followed when a man has had considerable rewinding experience.

Fig. 3—Winding a skein on an adjustable shuttle. Details which show how to make this shuttle are given in Fig. 2.



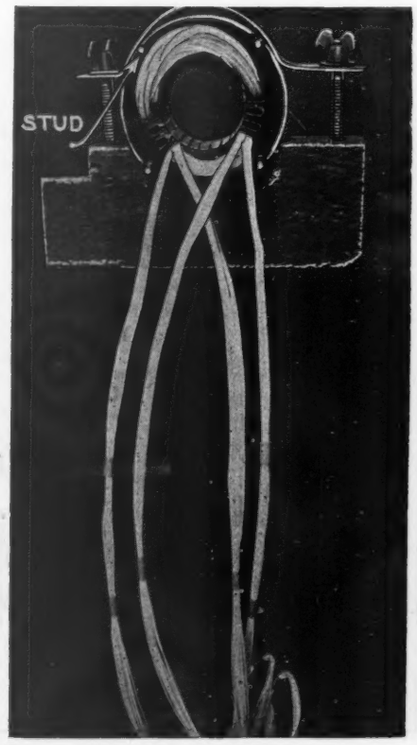
It is a good practice to employ the following rule for hand windings. Put down the number of turns per slot as shown in *A* and the upper part of *C* in Fig. 1. For skein windings put down the number of times the skein passes through each slot, as shown in *B* and the lower *C* of Fig. 1. Put the main winding data on top and the running winding at the bottom. When coils overlap denote it by using a diagonal dividing line, as shown. Note that in all these cases the length of the skein and the pounds of wire total is put down. The length of skein is the length of the completed skein and not the length of the entire wire before it is wound into the skein.

At *D* of Fig. 1 is the data for a two-pole motor. At *E* of Fig. 1 is the data for a skein-wound four-pole motor in which the coils do not overlap. The data in this case indicate that one slot is skipped between each adjacent running coil and the starting winding is passed through this slot four times. Also, the skein is passed through slots *C* and *A* twice, and through slots *D* and *A* twice, making four in *A*, two in *C* and two in *D*. If desired, this particular winding could be reconnected for eight consequent poles.

Insulating the Core and the Winding

Cut insulating cells of 0.007-in. fish-paper for the slots. These should be about ⅛ in. longer than the slot and should come just below the top of the slot. In addition to this a tan treated-cloth slider of the same shape should be used in each slot, or 0.007-in. fishpaper may be employed as a slider. When coils overlap a treated-cloth cell for the top coils should be cut ½ to 1 in. longer than the slot in order to protect one coil from another. Also in slots that contain both a running and a starting coil put a treated-cloth cell between the two coils. It is good practice to use 0.010-in. asbestos paper between the running and starting

Fig. 4—A skein winding partly completed on a two-pile stator.
The top coils represent one-half of the running winding, which is already in place. The other half of the winding has been started below. This is a split skein winding. One-half of the winding is shoved through the opening at a time and then the other half is brought through and placed in the same slot. Notice how the coils are placed with reference to the studs which hold the end bells of the motor in place. This picture also illustrates a convenient holding clamp.



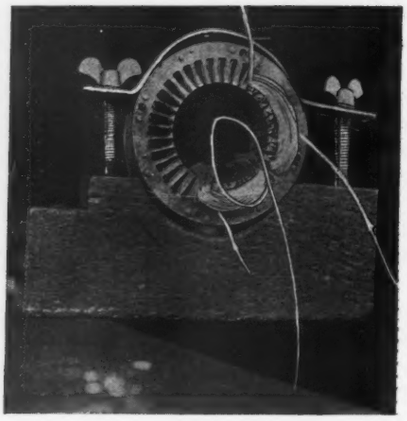


Fig. 6—This is the way the loops of a hand winding are slipped through the opening and into the slots.

A skein winding may be put on in the same manner after the winder has had some experience.

coils. The reason is that the starting winding is "nine times in ten" the one which burns out when the motor stalls. In some cases the starting winding is completely roasted out. If there is no insulation between this winding and the running coils the heat will burn the insulation off the running winding, which will cause short circuits and burning out of the entire winding. The use of asbestos paper will confine the burning to the starting winding alone. This winding is the easier to remove and rewind.

It used to be the practice to tape the ends of coils with cotton tape. Usually this is not needed, but the ends must be tied together with a cord. However, in cases where the winding is exposed to dust, etc., the ends should be taped. In any case dip the motor after winding in a good baking varnish and bake.

How to Make a Skein

In all small alternating-current motors use single-cotton-and-enamel-covered wire. After the length of the skein is determined, as already described, it is wound by means of a contrivance such as that shown in Figs. 2 and 3. The pegs are set at the proper distance and the device is turned on its axis until the proper number of turns are put on. Then the skein is taken off and wound on the motor stator.

Winding a Skein on the Stator

The drawings in Fig. 5 show the different steps in putting a skein in a stator. Fig. 4 shows a two-pole stator with one coil in place and the second coil partly wound. This also shows what is known as a split skein which will be described later. When the size of wire is larger than No. 19 and the total turns per skein make a bunch ½ in. square or larger, the skein is wound in two sections to make it easier to handle.

The different steps shown in winding the skein in Fig. 5 follow the data in *A* of Fig. 1. At *A* of Fig. 5 the skein is shown started in slots 4 and 7 with the lead end of the skein at the bottom of the drawing. This satisfies the center part of the data shown in *A* of Fig. 1. This data is 1-0-0-1, so that the winding is in slots 4 and 7 and two slots in between are skipped.

Fig. 5—Steps followed in putting on a skein winding.

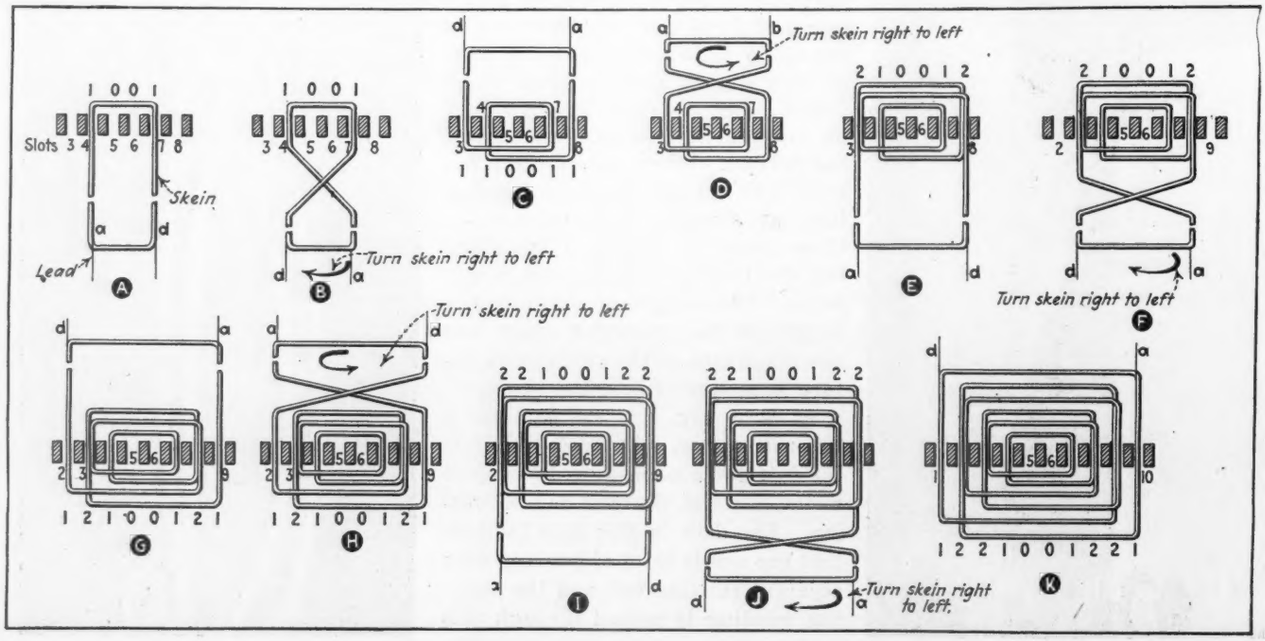
This is the running winding of the motor for which data is shown in *A* and *B* of Fig. 1.

Fig. 7—In hand winding steel rods are placed in the slots which are to be left vacant when putting on the running winding.

The wire is wound around underneath these rods, which hold the coils down and reserve room for the starting winding to be put on later.

Winding Must Be Started in the Proper Place on a Stator

In most cases it is necessary to start the winding at a certain point on the stator. With the repulsion type of motor the coils must be put back in place in the same arrangement as the original coils. If they are shifted with reference to the brush ridging it may be difficult to fit the brushes so that the motor will operate correctly. The neutral mark and the rotation mark on the brush shell will have to be relocated. If


Slots 3 4 5 6 7 8
Skein
Lead
Turn skein right to left
Turn skein right to left
Turn skein right to left

the coils are shifted too much the motor cannot be made to operate properly.

In any type of motor care must be taken to start the winding at such a point that when completed it will not rub against the studs or bolts which pass through the core and hold it together. Fig. 4 shows how a coil should be placed so that the thick or high part of the completed winding falls in between the studs. If this is not done the high part of the winding will rub upon the bolt when the motor operates and this will result in grounding the winding. Fig. 4 shows a two-pole stator, which is one of the hardest to wind and shape. The upper coil shows the proper position for a two-pole coil in reference to the studs. The lower coil, which is just started, is in the proper position for a completed four-pole winding. A general rule for locating the coils for two poles and four studs is that the outer coils should lie in the slots midway between the studs. For four poles and four studs the outer coil, or the last one wound on, should lie in the slot above the studs.

The first turns of the skein should be shaped to conform to the curvature of the stator bore. They should be bent down to allow room for the starting winding to be placed on top of them. Fig. 4 illustrates this method of shaping the coils. Care must be taken to keep kinks and twists out of the wire. Also each coil must be pressed tightly against the core and against any other layers of coils which have been put in before. If this is not done there will not be enough of the skein left to make the last turn of the skein.

After the first turn is put in the slots as shown in *A* of Fig. 5, the skein is twisted as shown in *B*. The right-hand side of the skein is twisted over the left-hand side so as to make the part "*a*" change place with the part "*d*." The skein is then bent over and pushed through the opening in the stator and the side "*a*" is threaded into the slot 8, while the slide "*d*" is threaded into slot 3, as shown at *C*. The skein is twisted again as shown at *D*, and pushed through the hole in the stator and threaded again into slots 3 and 8. This leaves the winding as shown at *E*, which satisfies the directions 2-1-0-0-1-2. At *F* the skein is twisted ready to push through and thread into slot 2 and 9 as has been done at *G*. Another twist is made at *H* and the skein is brought back through slots 2 and 9, as shown at *I*. The remaining length of skein is given another twist as at *J* and threaded into slots 1 and 10. This completes the coil and satisfies the entire winding data, which is 1-2-2-1-0-0-1-2-2-1. It makes no difference which way the skein is twisted each time as the polarity of the coil will not be affected, nor will the coil sides neutralize each other after a change of twist.

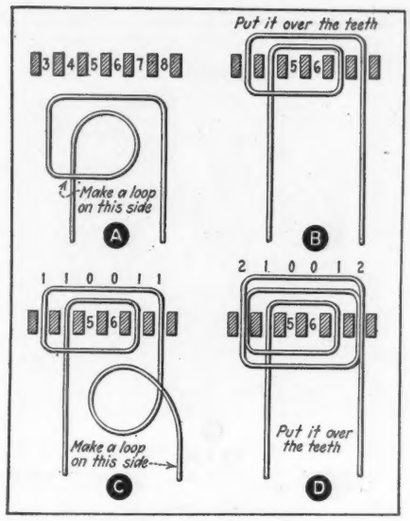


Fig. 9—A hand winding is put on a stator in this way.

After a little experience a man can put a skein winding on in this manner. It is a good deal easier than the method shown in Fig. 5 as the entire skein does not have to be brought through the opening in the stator.

Easy Method of Skein Winding for an Experienced Winder

The method of putting on a skein winding which has just been described is the one which involves the least possibility of making mistakes. A study of this method should result in a clear understanding of the principles of skein winding and of the position of the skeins upon the stator. There is, however, a quicker and easier method of winding a skein which may be used by a man who has had some experience. This method does not require pushing the entire skein through the small stator opening. Instead a small loop is made in the skein and this alone is shoved through the opening, after which it is fitted into place in the slot. The drawing in Fig. 9 shows this method and Fig. 6 shows the same principle in use with a single wire in a hand winding job. In winding with this method a twist or a loop similar in shape to the small letter "*e*" is put first in one side of the coil and this loop is slipped through and the wires are placed in the proper slot. Then the loop is made in the other side of the coil and the second loop is slipped through. A little practice will enable a winder to master this method.

Sometimes It Is Better to Use a Split Skein

As already mentioned, when the wire is larger than No. 19 and the skein is over ½ in. square, it should be wound in two sections to make it easier to handle. When winding the skein upon the shuttle half of the total turns are wound on, then the skein is tied in two places with a cord or tape. Without cutting the wire the rest of the skein is wound

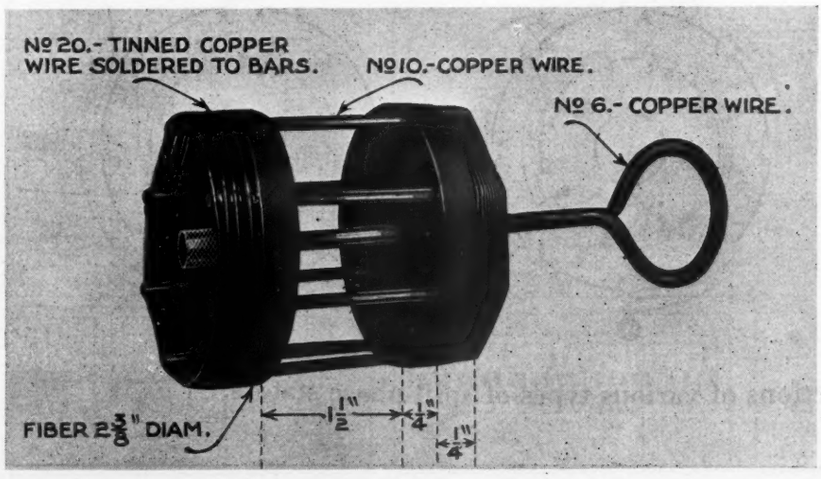


Fig. 8—A small dummy rotor used to tell the direction of rotation.

When this rotor is held inside the opening it will revolve in the same direction as the real rotor will turn when it is put in the motor. This little rotor may be used for testing the direction of rotation of large motors. It is held inside the stator close to the iron and moved around the core.

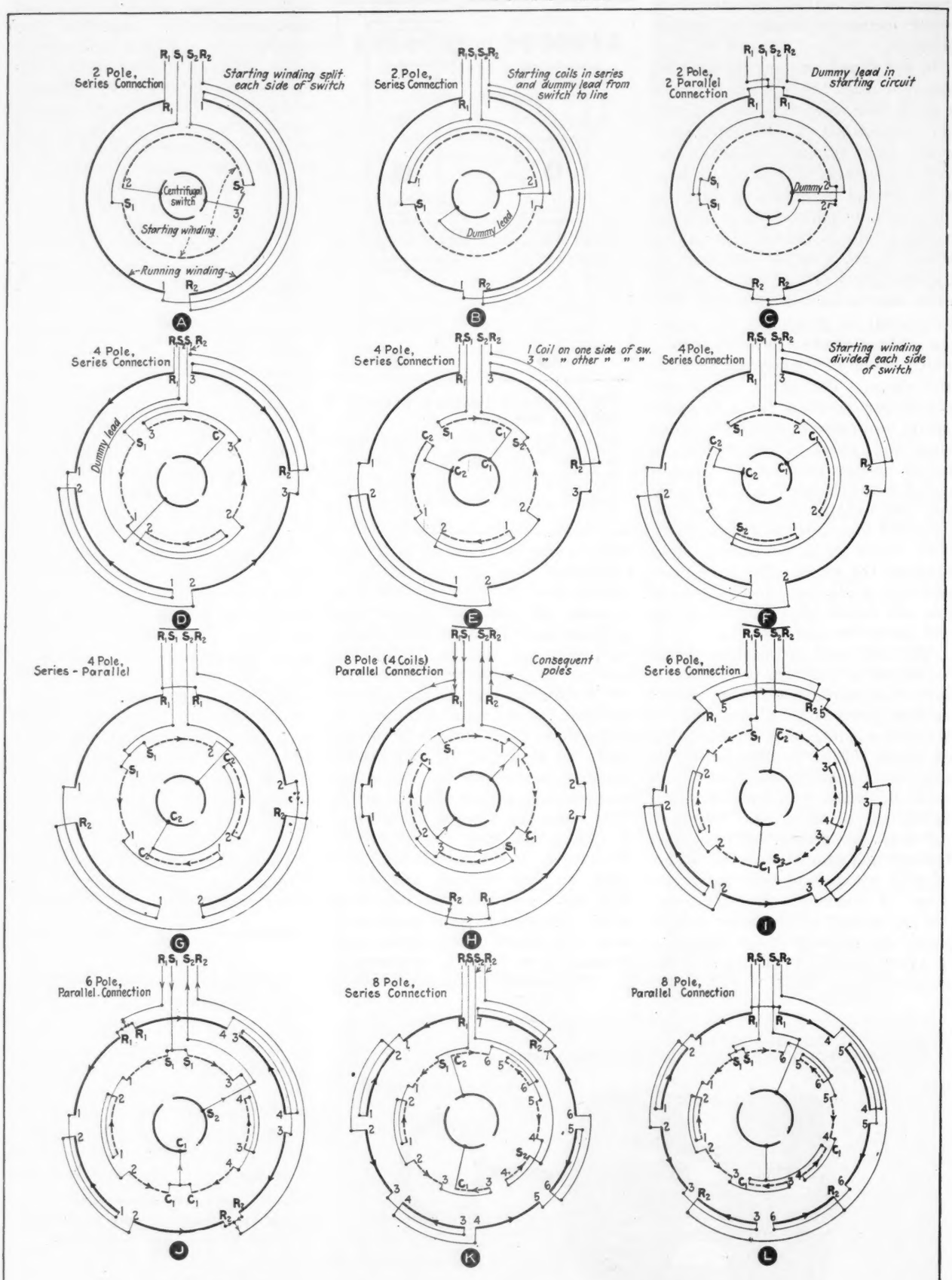


Fig. 12—Connections of various types of split-phase stators.

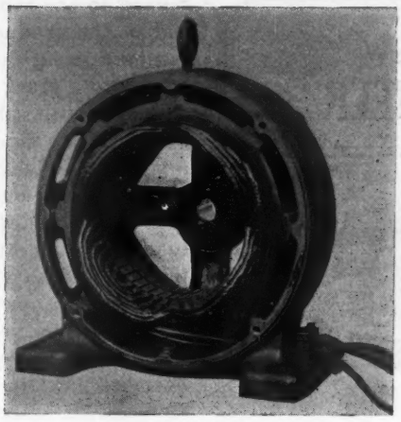


Fig. 10—A coil-wound stator of a single-phase motor.

This differs from the usual repulsion motor in that the coils are wound before being placed in the stator. The motor is a four-pole single-phase machine. It has six coils per pole in a concentric chain winding. The sixth coil of each group overlaps the sixth coil of the adjacent group. Six sizes of coils are used, four of each size. Each coil is threaded in and then the ends are taped from slot to slot.

upon the first section with a space between. The crossover of the single wire from the first section to the second section should be made at the end of the skein opposite to the lead end. This crossover end is put in the motor first. The winding is started in the same way as when winding a skein which is not split. After the winding is in the first two slots, however, before the first twist is made the two halves of the winding are separated. Then the twist is taken in the top half of the skein and this is shoved through the opening of the stator, and the coil sides are put in place in the slots. Then the other half of the skein is twisted and it is shoved through and the coil sides put in place on top of the preceding ones. In Fig. 4, the upper section of the skein is shown crossed ready to put through the slot. After both sections are put through the slots the stator is turned around and the operation repeated. This time the lower section of the skein is on top.

With the split winding as well as the simple skein winding, instead of shoving the entire skein through the slot the simpler method can be used as already described. This is the method in which a small loop only is shoved through the opening.

When putting on the main winding in the slots in which the starting winding also will go, room must be left for the starting winding. Two or more loose fitting fibre wedges should be put into the slot into which the starting winding goes.

How a Hand Winding Is Put on a Stator

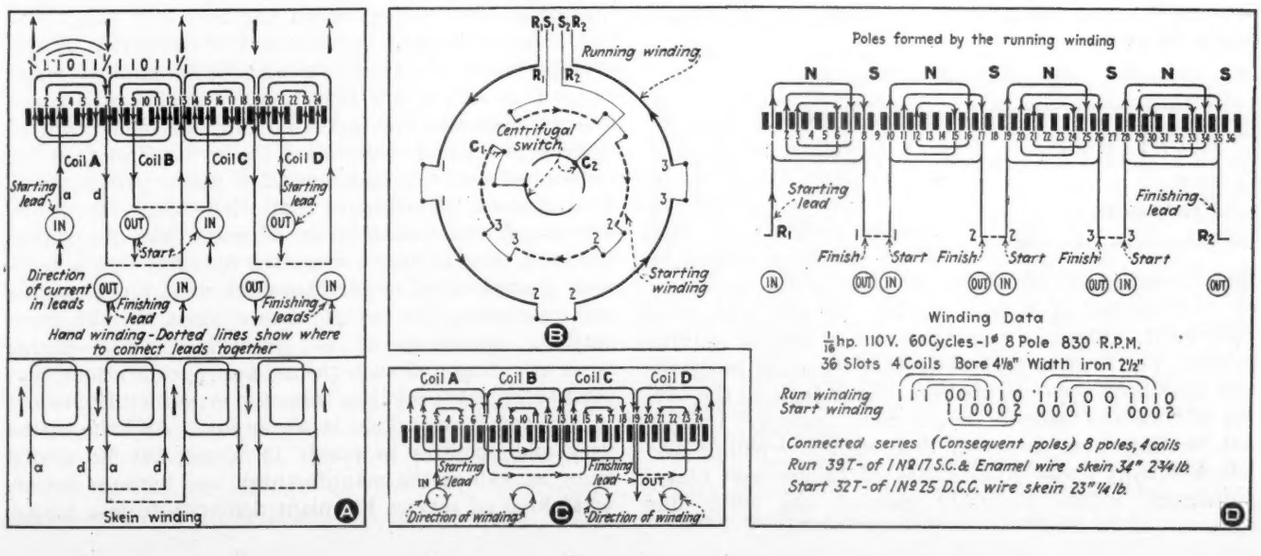
In a hand winding, one wire is threaded in at a time, the wire being unwound from a full reel and cut at the finish of each coil. This type of winding is resorted to when the wire is large or when the slots are high and narrow. In hand winding the wire is formed into a loop like the letter "*e*," as shown in Fig. 6 and Fig. 9. This loop is formed usually with the right hand, while the left hand guides the wire into the slot and forms it across the rear of the stator. To keep the winding from climbing up above the core, it is a good plan to use pieces of round cold-rolled steel, cut in 8-in. lengths. These should be about ⅛ in., 3/16 in. or ¼ in. in diameter. They should slide easily into the slots but be too large to pass out of the opening at the top of the slot. These bars are placed in the slots reserved for the starting winding and the wire is wound underneath them as shown in Fig. 7. The wire goes up to the bars but the slot holds them down so that there will be room for the starting winding.

Hand-wound coils are started in the two inside slots in the same manner as a skein winding. When these two slots are filled the next two are started. As may be seen from *A*, Fig. 11, slots 3 and 5 are first filled, then slots 2 and 6, and last slots 1 and 7. The last section of coil "*B*" also overlaps coil "*A*" in slot 7. In the winding shown in *A*, Fig. 11, the wire is cut after each coil is in place and the sleeving is put on. The coil ends are later connected up to form poles, as this article will tell further on. Each succeeding coil is wound in the same direction. For instance, the wire is started in slot 1 and wound across the back to slot 5 and then in succession to slots 2, 6, 1

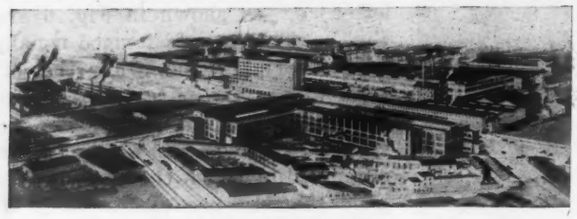
(Continued on page 256)

Fig. 11—Out-and-in method of connecting a skein or hand winding (A and C) and a special 8-pole, 4-coil winding (B and D).

In the upper part of *A* is shown the method of connecting up a skein winding after it is in place. At the lower part of *A* is a diagram showing the connections for a hand winding in which the wire is cut between coils. Note that in both of these cases when the current is assumed to come "out" of the finishing lead of one pole, it passes "in" on the starting lead of the next pole. The coils are all wound in the same direction, clockwise. It is not necessary to cut the leads of a hand winding if it is put on as shown at *C*. In this case, the first coil is wound clockwise,, the second is wound counter-clockwise, the third clockwise, and winding is continued in this manner. It will be noted that the coils form alternately north and south poles. A consequent-pole motor having four coils and eight poles is shown at *B* and *D*. The diagram shown here is for a series connection. A parallel winding of the same motor is shown in *C* of Fig. 12.


Coil A
Coil B
Coil C
Coil D
Starting lead
Finishing lead
IN
OUT
Start
Direction of current in leads
Hand winding - Dotted lines show where to connect leads together
Skein winding
A
R1 S1 S2 R2
Running winding
Centrifugal switch
Starting winding
B
Direction of winding
C
Poles formed by the running winding
N S N S N S N S
Winding Data
1/16 hp. 110V. 60 Cycles - 1ϕ 8 Pole 830 R.P.M.
36 Slots 4 Coils Bore 4⅛" Width iron 2½"
Run winding
Start winding
Connected series (Consequent poles) 8 poles, 4 coils
Run 39T - of 1N9 17 S.C.& Enamel wire skein 34" 2¾ lb.
Start 32T - of 1N9 25 D.C.C. wire skein 23" ¼ lb.
D

ELECTRICAL REVIEW
AND
INDUSTRIAL ENGINEER



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, May, 1922

When It's "We" and Not "They"

WHEN talking with men about their work and the people for whom they work, it is often noticed that the office executives and some of the heads lower down are referred to as "they." In some cases this may be simply a loose habit, but in others it emphasizes the failure to recognize that there cannot be a "they" in the right kind of an organization. If everybody is on his job and doing something worth while, it is possibly only through the support and assistance of those with whom and for whom he works, and when referring to this group it sounds a whole lot better to say "we." Besides, it indicates a kind of thinking that leads somewhere when the "we" includes a large group.

A story that brings out this point goes something like this: Three men who were working on a church were asked what they were doing these days. One said, "Just laying bricks." The second replied, "I'm getting ten dollars a day"; but the third said, "We are building a cathedral." It's not hard to guess which was doing the thinking, realizing that one day's work didn't just lead to another and that when the work of himself and his fellows was finished, it would be a monument of accomplishment, something of which all interested might be proud.

Electric Welding as a Profession

AN interesting phase of industrial progress is the constant creation of new trades or callings. A case in point is the field which has been opened by the increasing use of electric arc welding for the repair or reclamation of a wide variety of iron and steel equipment. Electric welding is not a new or untried process, but it is only recently that its great possibilities have been demonstrated on a large scale in the saving of time and material, which means money. It must not be forgotten, however, that electric welding also offers equally great possibilities of failure and disappointment unless skillfully carried out with due regard to the conditions which have been found essential to the production of good work. Electric welding means a great deal more than melting a piece of iron wire into a crack or seam by means of the electric current. If this physical action is to give the results desired there must be back of it suitable equipment and a good deal of diversified and yet specialized knowledge.

If anything but routine work is to be handled, there is need of a designer or supervisor with a thorough understanding of the principles of arc welding, supplemented by a broad mechanical knowledge, to specify intelligently how the parts shall be prepared and the form of joints and welds to be used, in view of the conditions of service to which the part is subjected. Moreover, he must have a sound knowledge of the composition and the effects of heat on the various kinds of iron and steel, in order that directions as to when and how work should be annealed may be properly given. And at the welder's bench there must be a conscientious workman who knows by observation and experience how good welds should be made, who has demonstrated his ability to make them consistently. This is clearly brought out by Mr. Wanamaker in his article on page 218 of this issue.

There is nothing haphazard about arc welding, nor are good welds ordinarily the result of chance or guesswork. To produce them requires, on the one hand, a sound grasp of the factors and principles involved, and on the other, the skill obtained by putting these principles into practice. And there is a wide field with attractive possibilities for those who are equipped with this knowledge and experience.

What Information on Motor Service Do You Keep?

IT seems a little strange that after more than 35 years of experience with electrical service we should actually know so little about motor applications from the standpoint of operating and maintenance costs per unit of output, as a check on the good or bad practice they represent. Manufacturers have built good motors and they have performed remarkably well, even when roughly treated. They have performed so well, in fact, that few users can say just what the life of a motor in years really is. Motors have been bought and placed in service without considering much more than the horsepower rating, speed and first cost. But conditions are changing, because service conditions in the average plant are changing and being studied much closer than only a few years ago. Machine production is being measured and increased and individual machine units with separate motors are the style. This calls for something more than guesswork on motor performance. It is, indeed, unfortunate that when these conditions are brought to the attention of more than one manufacturer, they at once plunge the operator into a technical discussion of motor characteristics, temperatures and insulation, the design, frame sizes, weight, competitors' arguments of the 40-degree and 50-degree basis of rating and such theoretical considerations that most technical specialists in motor manufacture are not in agreement on. This is all wrong. And the motor user and operator is partly to blame, for he should know as well as the manufacturer, and perhaps better, what kind of service his plant demands from a motor.

If he don't know, now is a good time to find out, for right here is a place to start to eliminate the technical discussions that so often simply confuse him. When details of service conditions and operating costs are known, the selection of a good motor requires little more than common sense when dealing with reputable motor builders, and there are only a few of the other kind in the business.

What is needed most now, to combine with common sense in motor applications, is more definite service information in all kinds of shops using similar machines but working on different kinds, shapes and sizes of materials. Such a study we plan to make in this publication and while it is being conducted we invite everyone interested to offer suggestions and points that they would like to see covered. Pet ideas and theoretical discussions will be respectfully listened to, but the presentation of this subject is planned on a basis that "he who runs may read," and from this standpoint suggestions will be particularly welcome.

Advantages of Industrial Electric Heating

ELECTRIC heating for ovens and other industrial equipment is a fairly recent development, compared to some of the other applications of electric energy, but it has made such great advances during the past few years that there is no longer any question of the advantage which it offers.

Many operations which involve the use of heat, for instance, heat-treating, annealing, core-baking, japanning and so on, have been successfully conducted with electrically heated equipment and the reasons for this success have been the same in all cases. This form of heating gives absolute control of the temperature and renders easily possible the duplication of the desired conditions with each load of work that is delivered to the oven.

The production of japanned work of the standard required on automobiles demands that sufficient ventilation be provided to remove quickly all products of the evaporation and oxidation of the thinners and oil used in the japan; that dust be excluded to the greatest possible extent and that every piece of work be heated to the proper temperature for a sufficient length of time to bake the film to the desired extent. Maximum production demands that these conditions be duplicated with every load of work and with the minimum amount of attention on the part of the operator.

The close control of the temperature and the uniformity of the heating have enabled the electric oven to meet these exacting conditions easily. In addition to the savings which have resulted from the greatly reduced amount of rejections of improperly baked work the electric oven has increased production markedly by allowing the use of considerably higher baking temperatures, thus shortening the baking period, and also by its greater advantages encouraging an increased use of continuous production ovens.

The fact that the actual cost per B. t. u. may be greater for electric heat, as compared with gas or oil. is more than balanced by the greater efficiency and increased production possible; so that electrically heated equipment with its accurate and easy control (which may be automatic, if desired), low maintenance expense, flexibility, and absence of fire risk, offers a very attractive solution of many industrial heating problems.

Don't Wait Until Accidents Happen

"WHEN it is necessary to use makeshift methods, something is wrong. It indicates a failure to plan and get ready beforehand," said one prominent industrial executive recently in talking about manufacturing methods. This is just as true, however, in maintenance and repair work. Of course, all breakdowns cannot be anticipated and prevented; some are the results of accident or carelessness, but even these can be decreased by safety starting equipment, protective devices and the proper training of those who handle the equipment. On page 180 of the April issue of ELECTRICAL REVIEW AND INDUSTRIAL ENGINEER, Orville F. Long, in his article on the "Central Control of Motors," showed how he has eliminated makeshifts in operation by providing central control and so removing all responsibility for the operation of the electrical equipment from the operator of the machine.

Those in charge of maintenance can find many ways of anticipating accidents. For example, regular inspection of motors, oiling schedules, load studies, periodic testing where load conditions are severe, all help anticipate breakdowns, because a breakdown of a machine, like that of a human being, usually comes as a result of long abuse, overwork, neglect, or improper conditions. Even though the best of care is taken in anticipating and thus preventing a breakdown, those which occasionally do happen must be taken care of. To do this efficiently requires that some thought be given in advance, or each job will be a hurry-up, rush job with the "haste that makes waste." A careful study of motors on hand will show a maintenance man how much he can prepare for repairs ahead of time. This study will show whether it is feasible to have spare motors so that a quick change can be made and the repairs made at leisure. This also will show how far the maintenance man can go toward carrying repair parts, ready-wound coils and other materials which may be prepared in advance. Even little things count, such as being sure that wire, solder, insulating material and fuses, which may be used on practically any job, are on hand. Then when the supply of repair material runs low do you know what procedure insures immediate reordering to prevent being caught without it?

Another thing that should be always on hand is the data and instructions for doing a job. After a motor or any other piece of equipment has been repaired once, it is unnecessary to waste time to again study out the wiring diagram before starting the work. Information should be already recorded on the first job to show just what material was needed and how to do the next job of the same size and type. A. C. Roe, in his article in this issue on rewinding small alternating-current motors, gives one practical method of recording this information so that it may be convenient and usable for future emergencies.

In any emergency the man who is ready has a big advantage over the man who waits until then before he even thinks about what he is going to do.

A Question And Answer Department You Shall Have

To Use and to Make Just as You Want It

YOU WIN! The vote for the Question and Answer department was "yes" loud and prolonged. And more than that, you have shown the kind of interest that means business, for with the requests for the department have come questions on a wide variety of subjects. Not all of these can be published at once, but a few of the ones received first appear in this issue. Now for the answers from your own experience on the jobs you have worked out. Sometimes the fellow asking the question may call to your mind a precaution or another trouble liable to be run into in solving the one he brings up. In that case, steer him off the rocks by pointing out what to look for and how to proceed. If you do your part this department of the paper will be the basis of an operator's handbook on all sorts of industrial problems.

Just to start the ball a'rolling, I have sent out a few of the questions that came early to some of the fellows who have liberally contributed to the "Service Around the Works" and "In the Repair Shop" departments. Some of their answers appear on the opposite page. Certainly Messrs. Roe, Rich and Walsh are to be congratulated on the speed with which they work, for their answers were received by return mail. You can't allow them to monopolize all of the talking space of the department, however, so let's get busy and make this section radiate experiences from all parts of the country. First come will be first served in the use of their questions and answers —that's fair, isn't it?

Now if you don't like what some fellows say in this department and you don't agree with them, just say so and so long as you don't call each other names you will run a good chance of getting your say published.

We want to make this part of the paper a place where one reader can correspond with all the others in his line of work throughout the country; a place where the man in Maine can know how it is done in California and the name and kind of fellow who is doing it.

It seems now that I am going to be "the goat" in seeing that the printer gets the copy straight and plenty of it—so I need your help with answers, fast and lots of them. What do you say —are you on, fellows?

Practical Pete

Who Can Answer These?

Charges for Maintenance Service.—I have a number of motors which I am taking care of on a monthly basis. Please offer suggestions for a basis of rates for this service which has been found satisfactory in other locations.
Denver, Colo. W. C. M.

* * * *

Armature Winding for D. C. Motors.—Please explain how the proper size and number of ampere turns of wire are computed for d. c. motors of 1, 5 and 10 hp. I have a faint idea that in a two-path armature winding the current carrying capacity of the wire is one-half the total ampere rating of the motor and for a four-path winding, one-quarter of the total. But how are the ampere turns determined?
New Britain, Conn. H. R.

* * * *

Transformer Connections.—In the case of a three-phase, four-wire, 4400-volt distribution circuit with grounded neutral, please show the proper transformer connections and how the transformer coils are connected. Are the three phases 120 electrical degrees apart and should the secondary be grounded?
Ontario, Canada. P. R.

* * * *

Winding for Bell Ringing Transformer and Demagnetizing Hand Tools.—Here are two questions I would like to have answered by readers:

(1) What changes must be made in the winding of a 60-cycle bell ringing transformer for use on a 25-cycle circuit? The present winding is 1000 turns of No. 20

B & S and 100 turns No. 14 wire. The rating is 100 watts, 110-volt primary, 10-volt secondary.

(2) In our factory tool grinders with magnetic chucks cause considerable anoyance to mechanics by magnetizing their tools, such as calipers, and the like. Please explain a simple method for demagnetizing these tools.

Brooklyn, N. Y. A. D.

* * * *

Changing Speed of D. C. and A. C. Motors.—Please explain a practical method of increasing the speed of a. c. and d. c. motors about 20 per cent without rewinding them. I would like to know the principles involved in figuring out these changes in each case.

Alton, Fla. L. H. H.

* * * *

Rewinding Wave-Wound Armatures.—We have a wave-wound armature to rewind which has 32 slots and 65 bars with a coil pitch of 1 and 8 and a commutator pitch of 1 and 33. There is one dead coil making 63 coils in all. Please show how to work up a diagram of coil connections and explain what becomes of the two extra bars.

Detroit, Mich. R. C. A.

* * * *

Connections for Two D. C. Series-Wound Crane Motors.—We have a traveling crane operated by two d. c. series motors connected in series on 220 volts. These motors recently burned out and were sent outside for rewinding. The shop rewound them for 220 volts instead of 110 volts and refuses to make the job right. We do not want to rewind them if they can be connected as they are. The controller layout will permit me to wire the motors so that the field coils are in series and the armatures in parallel without changes. I would like to know if there is any reason why this connection will not work.

Would it be better to operate the motors in parallel with additional resistance inserted in the field coil circuits so that they can be connected in parallel also?

Owosso, Mich. J. E. P.

Answers Received

Varnish for Armature Coils.—Please advise what is considered good practice in impregnating and baking coils wound with cotton-covered enameled wire? What varnish is used, how is it applied, how long and at what temperature are the coils baked?

St. Louis, Mo. H. H. E.

* * * *

The best practice is to bake the coils for approximately one to two hours according to the size of coil at 200 degrees Fahr. in a ventilated oven to remove moisture. Then dip the coils while hot in a black or clear baking varnish. Use varnish fairly heavy, that is, the less solvent the better. Do not let the coils soak more than one to five minutes. Then bake eight to twelve hours at 200 degrees Fahr.

Detroit, Mich. A. C. Roe.

Questions Asked and Answered by Readers

This is a section of this paper where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

No-Load Current of a Transformer.—How much current does a transformer draw when the secondary is open?

Chicago, Ill. G. E. F.

* * * *

The no-load current of a transformer just about balances the core losses. A charge is generally made by the power company to compensate for this transformer loss.

New Britain, Conn. H. S. Rich.

* * * *

Bending Copper and Brass Tubing.—I would like to know what is considered a good method for bending copper or brass tubing so that it will not buckle or open at the seams.

Milwaukee, Wis. G. E. A.

* * * *

A good method to use in bending copper or brass tubing is to plug one end with a cork or wood stopper and then fill the tubing with melted resin or ceiling wax. The tube can then be bent without injury and the resin or the wax may be removed by heating. When large pieces of tubing must be handled, fairly good results may be obtained by filling the tubing with fine sand.

Honesdale, Pa. J. M. Walsh.

* * * *

I have found that copper or brass tubing can be bent neatly by filling it with melted resin or absolutely dry sand with resin on each end. The sand must be dry or the steam resulting when heating the tube will burst it. I have also tried ordinary black tar as a filler.

After filling the tube and plugging the ends, heat may be applied by using a gasoline torch with a long blue flame played lengthwise along the tubing so that quite an extended area of the tube will be soft. This will allow the bend to be long and easy instead of in one spot.

If the bend can be made around some curved form, like the groove in an iron, rope-drive pulley, it can be formed easily and neatly. The tubing should be held slightly away from the iron while heat is being applied to it or the iron will prevent the tube from getting hot. If the tubing has a seam in it, keep the seam on the inside of the bend.

New Britain, Conn. H. S. Rich.

* * * *

Changing 25-Cycle Motor for 60-Cycle Operation.—Please explain how to reconnect a 25-cycle motor for use on a 60-cycle circuit when the number of poles remains the same. How will the horsepower vary?

Cleveland, Ohio. W. F. G.

* * * *

The horsepower will increase in the same proportion as the frequency, providing that the voltage is increased in the same proportion, or a corresponding change made in the connection, so that the back or counter E. M. F. of the motor will be the same as the original.

Adrian, Mich. C. A. Johnson.

* * * *

Plugging Holes in Slate.—What is a good substance to use to fill holes and cracks in slate switchboard panels? I have tried plaster of paris and shellac but when this compound dries it shrinks and leaves a space between the filling and the slate.

Boston, Mass. H. S. K.

* * * *

Make a paste of litharge and glycerine and fill the hole or cracks with this substance, which will air dry in one or two hours, depending on the space filled. For best results make the paste about the same consistency as workable putty. Litharge can be purchased at any drug store and comes in red flakes or powder.

Detroit, Mich. A. C. Roe.

* * * *

The best filling I have found for a hole in a slate panel is Early's commutator cement. When this is mixed up rather stiffly it will set in a short time without shrinking. While the surface is still moist, some slate dust should be spread over it and pressed in to give the patch the same color as the panel.

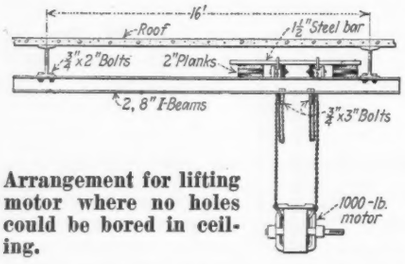
New Britain, Conn. H. S. Rich.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

A Simple Rigging for Suspending a Thousand-Pound Motor Near the Ceiling

THE problem of how to suspend a heavy motor from two I-beams 16 ft. apart and 18 ft. overhead was worked out very satisfactorily in one factory when a new motor was installed to take the overload of the main shaft, which was parted at a nearby coupling. As the motor was to retain its base, two other I-beams with 8-in. web were drilled for mounting on the roof beams, then hoisted with tackles and fastened into place with eight ¾-in. x 2-in. bolts, as shown in the drawing. A cord was stretched from the edge of the driven pulley to the point where the motor pulley would have to line up. By measuring along the beam, the first base-bolt hole was located. From this, the hole opposite was laid off with a large steel square, and being guided by a templet the other two holes were readily marked. All holes were put through with an electric portable drill. Four square-head bolts ¾ in. x 3 in. were used to mount the motor base. The motor was located near one end of the beams so as to reduce vibration.



Arrangement for lifting motor where no holes could be bored in ceiling.

Although the roof boards were only 14 in. above the motor, no holes could be bored for eye-bolts to hold the tackles and therefore blocking and a bar had to be used instead. Short pieces of 2-in. plank were accordingly piled on top of the new I-beams directly over where the motor housings would come, which points were located by using a plumb line. On these blocks was laid a solid steel bar 1½ in. in diameter onto which were hooked two one-ton chain tackles. The distance to the floor was 18 ft. and the hook chains were only 12 ft. long, so some scheme had to be devised for lifting the motor. The housings were reversed, and two other chains used to lift the motor 10 ft. A third chain was then slung over an I-beam and hooked to one housing; then by lowering the off tackle, the near tackle was released from its extra chain and hooked directly to the housing. This was repeated at the other end of the motor; then by lifting evenly, the base was brought up against the I-beams and bolted. All bolts in the base and motor feet were made in the shop, allowing an extra length of an inch for two nuts and a cotter pin on each, for absolute security.

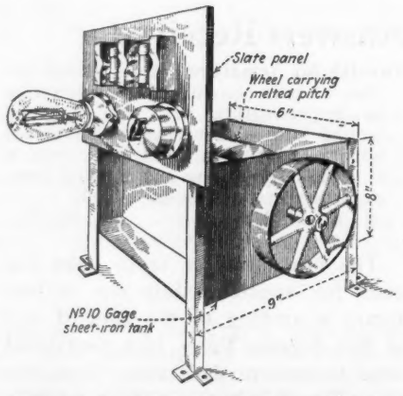
The motor was suspended without the pulley, thus allowing a small level to be placed on the shaft before bolting up tightly.

The whole job was done by two millwrights and two helpers.

East Berlin, Conn. H. S. RICH.

How Pitch Is Applied to Shoe Parts by Electrically Operated Machine

AN ELECTRICALLY operated machine is employed for heating and applying the pitch used in making shoes in the Hamilton-Brown Shoe Company, St. Louis, Mo. The machine is constructed of a No. 10 gage sheet-iron box or tank 9 in. long, 6 in. wide and 8 in. deep, with one end set further in than the other for protecting the heating elements and wiring from the pitch. A slate panel is mounted on one end of the tank and extends over both sides to prevent hot pitch from getting on the switch, pilot lamp and service box connections, which are installed on the side of the panel away from the tank. The tank is supported by four short angle-iron legs and is placed on a work bench when in use.



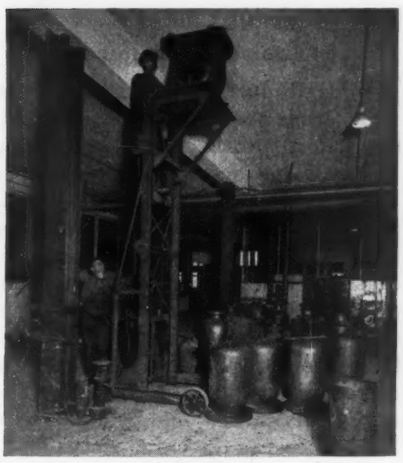
Pitch is heated in the tank and lifted for application by the revolving wheel.

Passing through one side of the tank and supported against the other side is a shaft with a driving pulley on the outer end and a 6-in. pulley with a 1½-in. flat face running through the hot pitch from a position of just touching to 3 in. or more in depth. The parts to be coated with the pitch are brought into contact with the face of the pulley. It revolves at a speed of 50 r.p.m. and about 1/10 hp. is required to drive it. Directly under and along one side of this wheel are installed three electric radiators constructed of cast brass tubes 1¼ in. diameter and 5½ in. long, closed at one end and flanged at the other end. A companion flange affords the means of fastening them into the end of the tank with asbestos sheet packing to prevent leakage. Holes are cut in the tank for the reception of the radiators and the heating elements which are 150-watt, 110-volt cartridge units pushed into the brass radiators. These heat the pitch to 310 deg. F. The tank, when properly filled, holds about 3 lb. of composition pitch and will coat about 380 shank pieces per pound with the proper amount of material.

Chief Engineer, Hamilton-Brown Shoe Co., St. Louis, Mo. ALBERT KOCHS.

Increasing Speed and Safety When Installing Heavy Equipment Overhead

INSTALLING motors or other heavy equipment overhead or taking them down for repair or overhauling is something which most maintenance men dislike because considerable extra rigging or blocking is usually required to do the job. This makes the work slow and even with the best of care it is dangerous, especially if changing conditions make it necessary to use inexperienced men in the maintenance gang. One large company has simplified this work and made it not only safer but quicker by using an Economy portable elevator with an inverted platform, as shown in the accompanying illustration. This platform can travel to the full height of the elevator and holds the motor in place while one man bolts it up or loosens the bolts to remove it. The inverted platform does not come clear to the floor as does the standard portable elevator platform. This makes it necessary to lift or lower the motor or other equipment about two feet to get it on or off the platform, which is a small job compared to the ease with which the remainder of the lift is made, since the platform is raised or lowered by one man cranking it up through gearing. Electric power may be applied to the elevator if desired.



Installing overhead work without blocking it up.
With this elevator a motor or other heavy equipment can be cranked up and held in position by one man in less than a minute. Compare this with the time required to build up the blocking which is ordinarily necessary. In addition, the danger of accidents is greatly reduced.

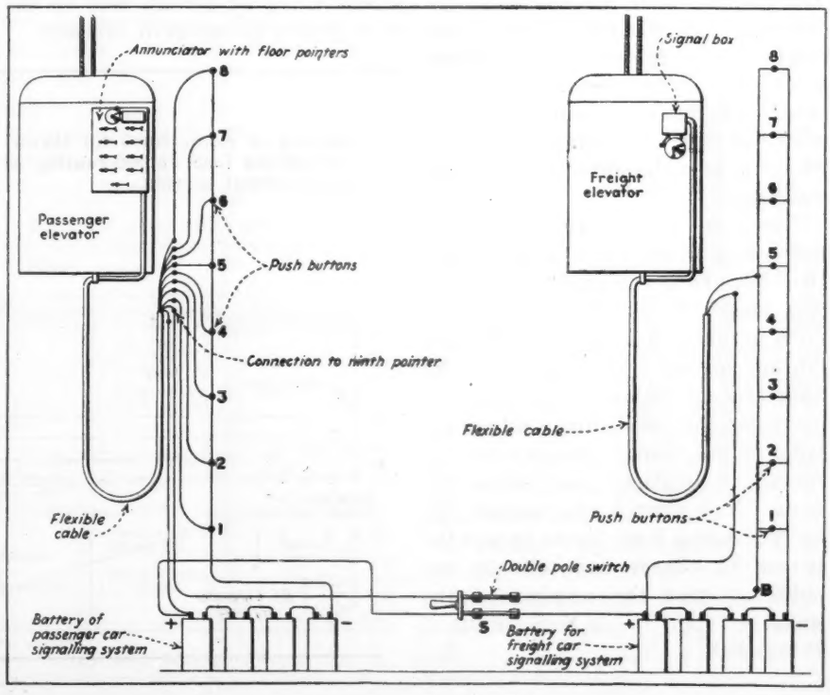
Countershafting, ceiling radiators, sections of heavy pipe, or any other overhead equipment can be elevated and held in place as easily as can a motor. Plants which have the standard platform portable elevator, which is ordinarily used in industrial work, instead of the inverted platform, can get the full height elevation by building up the necessary blocking on the platform. The Economy Engineering Company, Chicago, Ill., built this equipment.

Signal System Which Enables One Attendant to Operate Two Elevators on Holidays

A SCHEME which permits one man to attend to two elevators during periods when traffic is light was recently worked out for an eight-story building in a neighboring city. There are two elevators in this building, one for passenger service and the other for freight. These are located at opposite ends of the building. The scheme consisted in connecting an annunciator pointer in the passenger elevator so that it will give a signal and thus notify the operator when the button for the freight elevator is pushed.

The passenger elevator is equipped with a 9-point annunciator. Eight of the pointers correspond to the eight floors of the building. The ninth pointer is the one which is connected to operate when the signal button is pushed at any floor for the freight elevator. The accompanying diagram shows the method of connection. When the annunciator bell is rung from any floor at the passenger elevator, the pointer for that floor swings from a horizontal to a vertical position and thus signals the

The passenger car operator receives signals for the freight elevator on the ninth pointer of his annunciator.



operator. The freight elevator is equipped with a simple annunciator bell only. The operator is signaled from any floor by ringing this bell a number of times corresponding to the number of the floor. On Sundays the traffic on both elevators is very light. Employment of two operators for Sunday service seemed unwarranted, provided a simple system could be arranged for transmitting signals for the freight elevator to the passenger car. To solve the problem, the building engineer ran a wire from the terminal *A* of the freight elevator system to the ninth pointer on the passenger car annunciator. Another wire was run as shown from the positive terminal of the battery which supplies current for the signal system of the passenger elevator to the switch *S* and then to the positive terminal of the battery which supplies current for the freight elevator signal.

When the switch *S* is closed the two annunciators are connected in parallel across the batteries of the freight elevator signaling system. Both signal bells are thus made to ring at the same time when any button in the freight elevator system is pushed.

A. J. DIXON.

St. Louis, Mo.

Pilot Lamp Indicates Which Gong in Fire Alarm System is Ringing

IN THE plant where the writer is connected with the electrical department, the Grinnell Dry Valve fire-protection system is used. When a sprinkler head opens it rings an electrically-operated gong in the office of the telephone operator, which is also the office of the night watchmen.

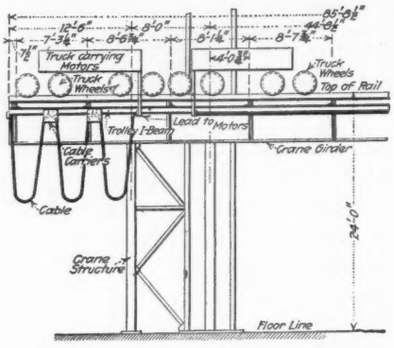
There are about fifteen of these gongs and on several occasions when they have rung the person in charge was unable to tell which gong was ringing, inasmuch as the hammers vibrate so fast that they cannot be seen from a distance. In order to overcome this condition, a miniature lamp of the proper voltage was connected in multiple just below the gong. Now when a gong sounds, the corresponding lamp lights up and the person in charge can tell the fire chief at once the number of the gong.

N. S. DAVIS.

Batavia, N. Y.

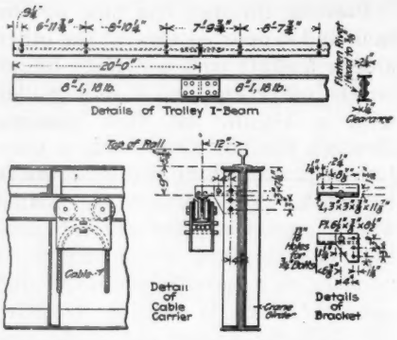
Flexible Cables Used for Crane Power Feeders

WHEN installing a manipulator crane beneath and at right angles to an overhead traveling crane in the forge shop, the Erie (Pa.) Forge & Steel Company found that the ordinary trolley system would interfere with the traveling crane operation. It was also impracticable to attach the trolley wires to the frame of the crane. The problem was finally solved by feeding the motors directly by a flexible cable. Ordinarily this cable would be difficult to handle because the crane moves back and forth very rapidly, but suitable



Scheme for supporting trolley wires of crane when ordinary method could not be used.

cable supports which eliminate this objection have been made. These cable supports consist of double-wheeled carriages which hold the cable and which are free to move on wheels along an I-beam held on the crane frame by means of brackets.



Construction details of special support for flexible cable feeding crane motors.

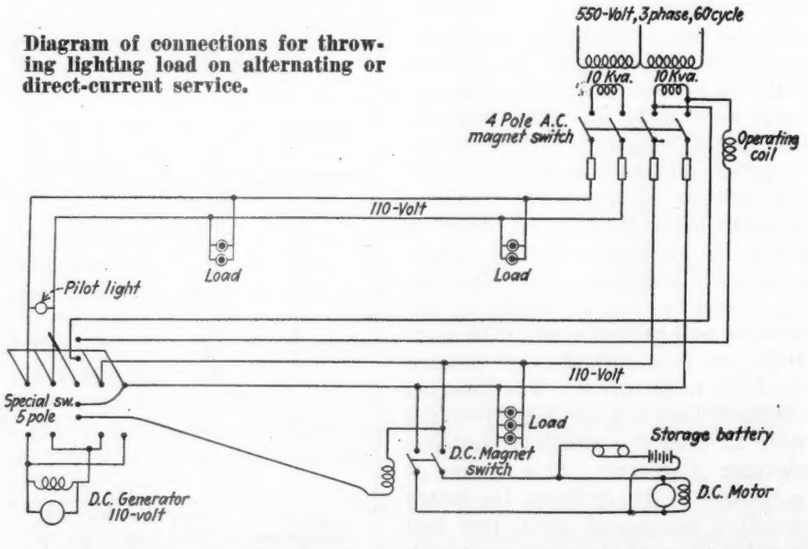
As the crane moves away from the side of the shop, the cable supports automatically distribute themselves along the steel runways. The cable is made long enough so that it will be horizontal when the crane truck is at the far end of the frame.

Switching System for Carrying Lighting Load from Alternating or Direct Current Service

A UNIQUE switching system was recently installed in an Eastern mill in order that the lighting load could be taken care of from two different sources of supply, one alternating and the other direct current.

The load, approximately 20 kw., was made up of lamps, a storage battery and a small direct-current motor. The direct-current service was two-wire, 110 volts and was originally supplied by an engine-driven, direct-current generator. When 110-volt, 3-phase alternating-current

Diagram of connections for throwing lighting load on alternating or direct-current service.



was brought into the mill, transformers were installed to take care of the out-of-hours lighting load.

The original lighting circuits were divided into two sections carrying approximately equal loads and from the diagram it will be noted that each transformer is arranged to take one-half of the total load. In order to prevent alternating current damaging the storage battery and direct-current motor, a magnet-operated switch was installed so as to be controlled from the direct-current generator switch in a similar manner to the alternating-current switch, which is also magnetically operated.

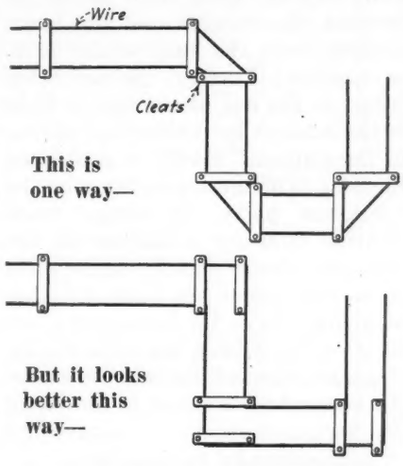
The operation of the system is extremely simple. When the direct-current generator is operating, the alternating-current magnet switch is open and the direct-current magnet switch is closed. When it is desired to change to alternating-current service, the direct-current knife switch is opened; this opens the control circuit of the direct-current magnet switch and closes the control circuit of the alternating-current magnet switch. There is but one point of control, which is at the direct-current generator, and inasmuch as the operator must go to this point to stop or start the direct-current generator, no extra steps are necessary. Further, it is impossible to put the two systems together. A pilot light was installed as a guide for the operator, to indicate that the alternating-current switch has operated before the direct-current switch is closed on the feeder circuits. A considerable amount of copper wire was also saved, since the two sources of power were a considerable distance apart.

WALTER L. HAMILTON.

Electrical Engineer,
Holyoke, Mass.

A Sloppy Wiring Job Is an Eye Sore

MANY times a new line of cleat wiring somehow or other does not look as neat as it might simply because some of the cleats are placed close together at a variety of angles. When they are placed parallel to



each other the appearance of the job is much improved and the conductors are just as securely supported. The illustrations show this very clearly.

H. S. RICH.

New Britain, Conn.

Heating of Circuit Breakers and Cables by Induction Easily Prevented

A CASE of overheated circuit breakers and cables recently came to the writer's attention. It was thought at first that poor contact in the circuit breakers caused the heating, but careful study showed that the transformer action of the iron parts of a supporting platform was responsible for the trouble. In the plant in which the trouble occurred there were two generators located on the generator floor. Circuit breakers controlling the current from the generators were mounted upon the wall of the same floor; they were rated at 2,000 amp. and were of the four-pole type. From these circuit breakers four 1,000,000 circ. mil cables passed through the floor of the platform to the buses above, as shown in the accompanying drawing. This made eight cables leading up from each circuit breaker. Generator No. 1 had been installed for some time and had given no trouble. Increasing load made it necessary to install a second unit, No. 2. When this unit was installed the cables were brought up from the circuit breaker, as shown in the sketch. Five of the cables passed on the right hand side of an I-beam imbedded in the concrete slab forming the platform, and three of them passed on the other side of the I-beam as shown. After the generator was in operation it was found that the cables and the circuit breaker heated excessively. At first it was thought that the trouble was with the contacts of the circuit breaker, as no difficulty had been experienced with the installation for No. 1 generator.

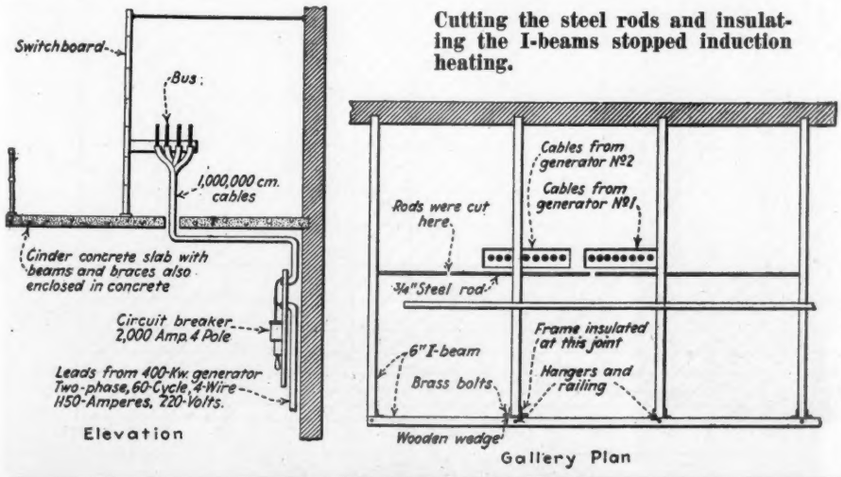
The question of inductive action was raised and to study the possibilities of such action, plans of the floor and switchboard platform were secured. By consulting these plans it was seen that closed magnetic circuits were formed by the iron used in the concrete platform. The 6-in. I-beam and the ¾-in. steel rods formed a continuous passage for magnetic flux.

The remedy was to break these magnetic circuits. This was done by chiseling through the concrete and cutting the ¾-in. steel rods in the center of each panel as shown. Furthermore, the end of one of the I-beams was insulated from the front I-beam of the platform. This was done by placing a wood block between the end of the I-beam which extended across the platform and the I-beam which formed the front edge of the platform. The iron bolts were removed and brass bolts were substituted at this point. This broke the magnetic circuit and entirely eliminated the heating.

A similar case of heating caused by inductive effects was described in ELECTRICAL REVIEW AND INDUSTRIAL ENGINEER for March, 1921, on page 142.

W. E. SEWARD.

Brooklyn, N. Y.



Cutting the steel rods and insulating the I-beams stopped induction heating.

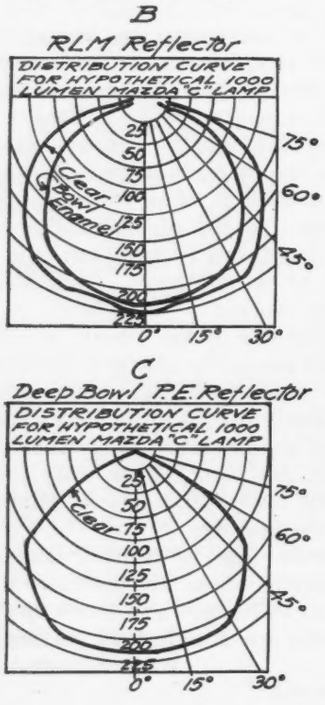
Graphic Solution of Lighting Problems

IN THE solution of lighting problems, especially for industrial plants, it is often necessary to estimate approximately the intensity of the light that will fall at a given point from a given lamp. For example, assume that a proposed lighting system has been determined by the "lumen" method, taking into account the various items such as lumens output of the units, utilization factor and the like—the system being designed for the desired average intensity of light upon the working plane. Investigation into the relation of lamp and machine location may show that certain operators may be in such a position that machine parts, possibly moving, will cut off the light from one or more of the general lighting units. This condition may make it decidedly important to be able to predict the intensity (contract) of the shadow cast.

The curves herewith, modifications of some published in the *Electrical World* several months ago, are helpful in making such predictions.

Reduction factors for solution of illuminating problems, and distribution curves for R L M and deep-bowl reflectors with hypothetical 1,000-lumen lamps.

The square of the distance between the lamp and plane of illumination, the angle of the beam and the corresponding reduction factor are all determined directly from this one chart. The typical distribution curves apply to lamps of various sizes; the proper method of reduction is described above.



In these curves the horizontal and vertical distances are measured from a point directly under the lamps. The intersection of the horizontal and vertical distance lines relating to a given point will, when referred to the oblique lines, show the square of the distance of the point from the lamp, and when referred to the diagonal (degree) lines show the angle between the vertical and the beam of light from the lamp to the point in question. Further, the reduction factor at the end of the degree lines is the amount by which the "square of the distance" should be multiplied in order to obtain the lighting on the horizontal plane. If vertical plane lighting intensity is desired use the reduction factor for the angle equal to 90 deg. minus the angle obtained as above. Thus, for horizontal plane lighting for 30 deg. we get 1.15; for the same beam of light the factor for the vertical plane would be the factor for 90 minus 30, or 60 deg., which is 2, as shown by the diagram.

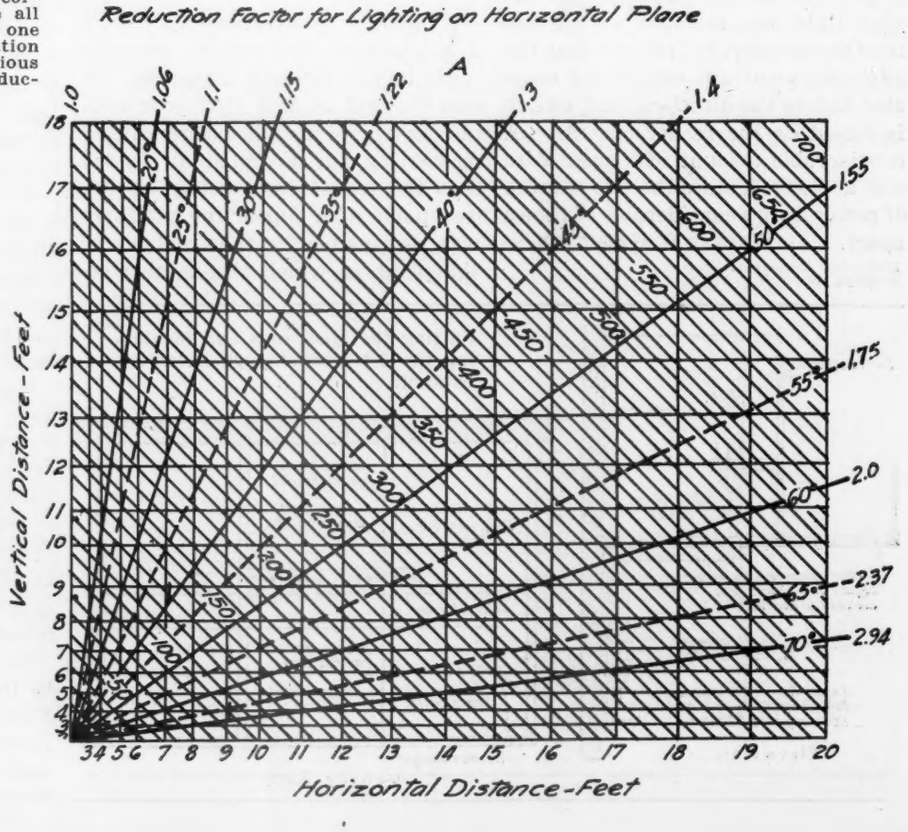
If hypothetical, 1,000-lumen lamp, candle-power curves are used, they may be easily adapted to any size of lamp. Example: Find the foot candle intensity of light on horizontal plane 6 ft. below lamp at a point 8 ft. from directly under the lamp. Assume the lamp to be a 3,100 lumen lamp with reflector as per Curve "B" (clear).

RATINGS IN WATTS AND LUMENS OF CLEAR MAZDA LAMPS

Watts		Lumens
50		480
75		865
100		1,260
150		2,040
200		3,100
300		4,840
500		8,750
750		13,900
1,000		19,300
50	White	450

The 6-ft. vertical and 8-ft. horizontal lines intersect on the 100 (square of the distance) line between the 50 and the 55 deg. lines, the factor at this point being approximately 1.63. From Curve "B" the lamp gives (155×3,100÷1,000) candle power along the 53 deg. line. Thus the intensity of light required in the example is as follows: (100 ×3,100÷1,000)÷(1,000×1.63) = 3 ft.-candles, approximately. For lighting on the vertical plane at this point, (155×3,100÷1,000)÷(100× 1.24)=3.87 ft.-candles. Now if this area happened to be midway between two lamps, with a small-area shadow because the light from one lamp is cut off by an opaque object, the shadow contrast may be in the ratio of 3 to 6 on the horizontal plane and of 3.87 to 7.74 ft.-candles on the vertical. This method is not adapted for use with a focusing type of reflector.

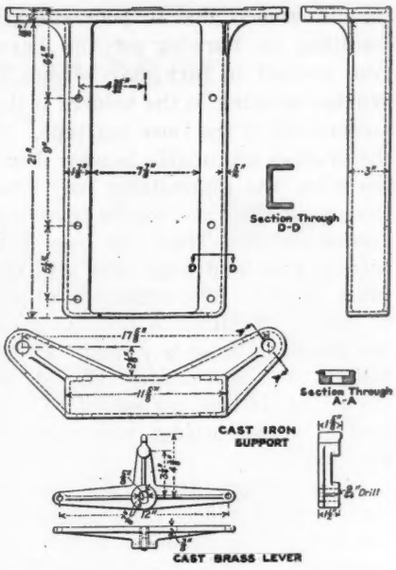
Electrical Engineer, Worcester, Mass. C. W. KINNEY.



Supporting Frame for Mounting Compensators on Ceilings

IN ORDER to save working space and wiring expense in the plant of the Dayton Engineering Laboratories Company, compensators are mounted on the ceiling by means of cast-iron supports. With the compensators so mounted, the motors are started by chains hanging down within easy reach of the operator. In this factory two different sizes of mounting supports have been found necessary; the one used for compensators up to 25 hp., rated at 220 or 440 volts, is shown in the accompanying photograph and drawing. A somewhat similar mounting, but considerably stronger, is used for motors of 30 hp. to 100 hp.

The compensator, as may be seen from the photograph, is bolted to the support. Three chains hang from the compensator, two of which are suspended from a brass arm mounted on the lever on which the starting handle of the compensator is usually attached. The construction of this arm is shown in the accompanying drawing. By pulling these chains the motor is started. The third chain is connected to the lever for tripping the compensator. One of the reasons advanced for the use of automatic compensators is that manufacturing floor space is saved by mounting them overhead or at a distance. The same saving of space, however, is accomplished with these supports. This method of mounting shortens the conduit to the run extending from the ceiling to the motor. It also facilitates inspection from a distance, as the inspector can see at once by the position of the starting lever whether the compensator is in the running, starting or off position. It has been found that this mounting does not materially increase the time required for periodical examination.



Cast-iron ceiling support and starting lever used for mounting low-voltage compensators up to 25 hp.

Compensators conveniently mounted on ceiling are easily operated by manipulating these three chains.

H. L. BURNS.
Chief Electrician, Dayton Engineering Laboratories Co., Dayton, Ohio.

Nine Safety Rules for Operating Arc-Welding Sets

RULES for the safe use of arc-welding sets which have been adopted by one Pacific Coast industrial concern have shown their usefulness through the reduction in accidents since their enforcement.

1. *Goggles.*—When more than one person is working in a booth, each must wear amber or blue goggles to protect his eyes from accidental flashes from adjacent arcs when his hood is off.

2. *Hood.*—Always wear a hood or use a shield with amber or blue-glass window for protection of the eyes and face against harmful ultra-violet and infra-red rays from the arc.

3. *Clothing.*—For protection against burns from incandescent particles expelled from the arc, closely woven clothing, gauntlets and leather shoes having bellows tongues should be worn.

4. *Cable.*—Always have cable above the ground so that it will not be stepped on. On scaffold or platform work run the cable under the platform so that it will not be tripped over. Keep all cables as far as possible from the arc.

5. *Ground.*—Be sure the material to be welded is properly grounded before starting to weld.

6. *Scaffold Work.*—When working on a scaffold be sure that hot electrode stubs or drops of hot metal will not fall on persons below the scaffold.

7. *Footing.*—Be sure you have a substantial footing before starting the weld.

8. *Ventilation.*—There must always be sufficient ventilation in the booth to keep it clear of fumes.

9. *Welding Booths.*—Welding must be done in a booth inclosed on three sides to prevent injury to persons working in the vicinity.

D. N. LOUIS.
San Jose, Cal.

Selecting the Proper Grade of Carbon Brush

IN CHOOSING carbon brushes the important points to consider are the contact resistance, the hardness or softness of the material, the specific resistance of the brush proper, the abrasiveness or ability to wear down mica and the lubricating quality. By proper selection of the materials used, brushes may be made to possess any of the above qualities in the desired degree. For example, abrasiveness may be increased by adding certain gritty or abrasive materials. Graphite increases the lubricating qualities and the contact resistance.

Frequently, in order to obtain the best results, it is necessary to use more than one kind of brush on the same machine. For instance, if gritty brushes are used to keep the mica down, it is often advisable to use one or two soft graphite brushes per stud to lubricate the surface. These should be staggered across the commutator. In a machine having high armature reactance the voltage of a coil when short-circuited produces a heavy short-circuit current from bar to bar under the brushes and high-contact-resistance brushes are often helpful in such cases. When graphite brushes are used for this purpose there should be one gritty brush per stud in order to keep mica down, since graphite brushes are soft and will not wear the mica. The gritty brushes should be thinner than the graphite. A few graphite brushes of soft grade used with other brushes may be helpful in certain cases, as the thin film or layer of graphite which is picked up and stays on the face of the carbon brushes increases their contact resistance without reducing their carrying capacity.

Commutator and brush trouble can frequently be eliminated or greatly reduced by a change in the grade of brush used. Thus, glowing and pitting indicates too heavy short-circuit current, and a brush of higher contact resistance will usually help to reduce this. Such trouble may also be caused by brushes being too wide and consequently covering too many bars. Picking up copper also may indicate too heavy short-circuit current, which can be remedied by using a brush of higher contact resistance. Too high current density in brushes and poor centering of the armature in the field also cause picking up of copper. Graying of the commutator face is usually due to poor contact resulting in burning of the bars. Poor contact in turn may be due to brushes sticking in the holders if the holders are of the loose box type. If the brushes are unable to wear down the mica, the commutator may first show very small pin sparks traveling around on it. Then the bars will become gray and high mica will develop rapidly. The remedy is to put on gritty or abrasive brushes with one graphite brush per stud. In addition the commutator should be stoned, or, if bad, turned off. Ordinarily, undercutting will not be necessary.

If the voltage between the bar and the brush is widely different at the toe and heel, as measured with a low-reading voltmeter, it will probably be advisable to use a thinner brush. If this test shows a reversal of voltage under the brush, a thinner brush is necessary. The voltage under the brush can also be equalized by stiffening the field or improving the fringing from the pole shoes. This gives a wider neutral which may relieve the necessity of changing the brush. Stiffening the field can be accomplished by shaping the pole shoes, but should not be attempted without a full knowledge of the results that may follow. Commutator heating often compels the use of thick brushes. On interpole machines a change in the thickness of brushes is seldom necessary.

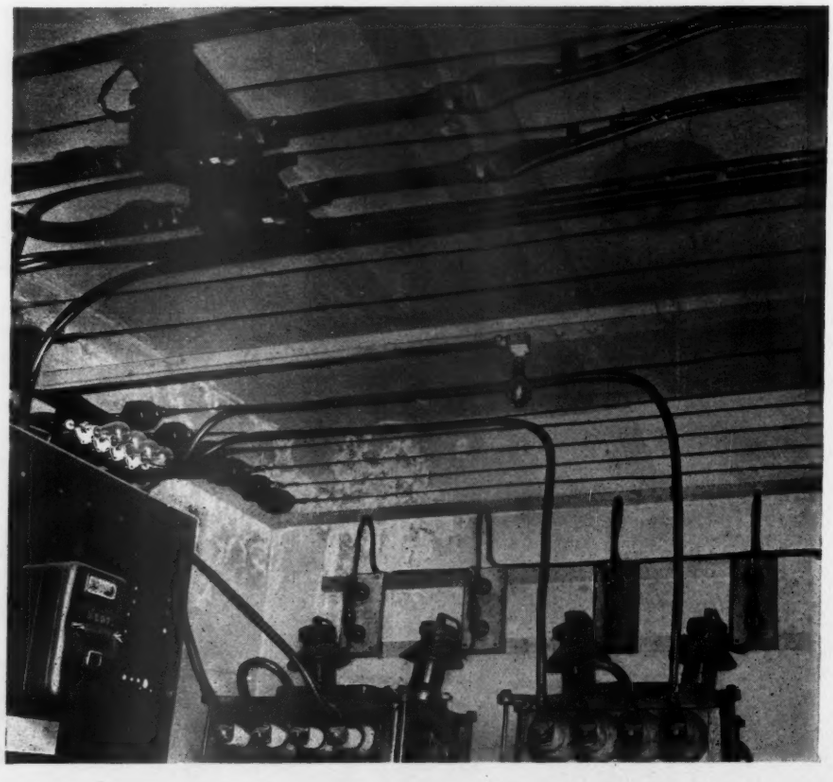
Steel Messenger Wire Supports Cables in Factory Substation

TO INSURE alignment with minimum sag and few supporting insulators, cables in the substation serving the American Bosch Magneto Corp., Springfield, Mass., are hung by tape loops from ¼-in. steel messenger wires attached to strain insulators at either end of the substation interior, as shown below.

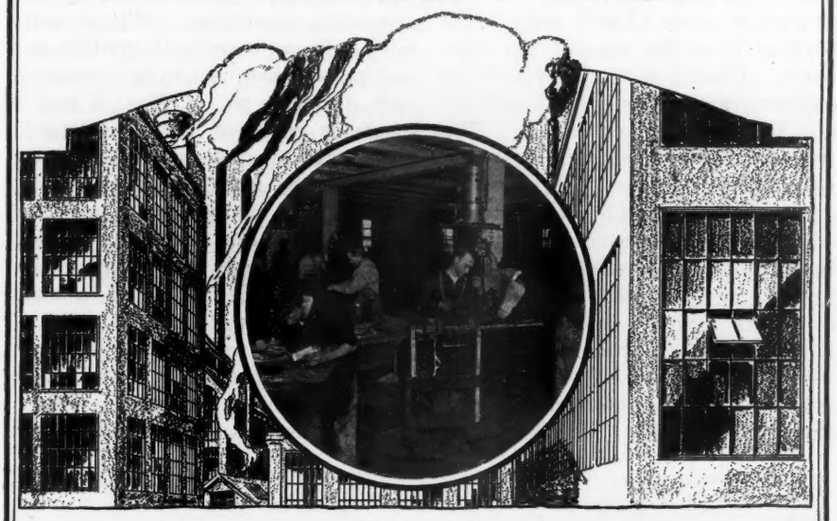
Two 250-kva. 5,500-to 440-volt single-phase transformers serve the plant. Two-phase local distribution is made from the substation by 400,000 circ. mil cables shown in the photograph rising from the secondary outlet bushings and making right-angled turns to the left from the right-hand transformer. The entire overhead wiring passing across the substation in 440-volt cable form is suspended in this way. The absence of sag not only improves the appearance of the installation but enables the Bosch company to be served by the shortest length of copper consistent with a symmetrical layout.

Boston, Mass. H. K.

A neat job requiring few insulators is accomplished by taping the cables near the ceiling to steel supporting wires.



In the Repair Shop



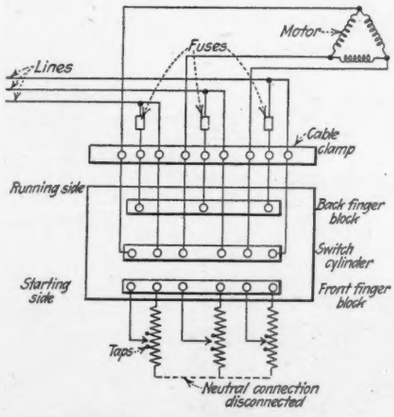
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Reconnecting 110-Volt Compensator for Emergency Use with 220-Volt Motor

A GENERAL ELECTRIC starting compensator used in connection with a 220-volt induction motor was damaged recently and before the necessary repairs could be made the motor had to be put back into service. A 110-volt, 25-hp. compensator was available and the writer found that by opening the neutral connection from the three compensator coils and reconnecting the taps so that the whole winding was in circuit the motor could be started as easily as though it were controlled by its regular compensator. Disconnecting the neutral connection leaves a winding in each phase acting as a current limiting reactance.

H. H. LOCKYEAR.

Bonnington Falls, B. C.



The neutral connection was opened and the taps reconnected to put whole winding in circuit for handling an emergency job.

Fillers Which May be Used for Plugging Commutators

SHORT circuits which burn themselves clear at the surface of a commutator often burn a hole in the mica and the bars. When the mica is not burned too deeply it is often possible to clean out the holes with a thin knife blade and plug them with a suitable filler. When a good job is done and the commutator kept free from oil the plugged sections will wear for a year or longer. It is always advisable to save the wearing surface of the commutator in this way whenever possible, for every time a commutator is turned down in a lathe about three years of its useful life is lost.

Fillers which have been successfully used for plugging commutators can be made up as follows: Two parts of plaster of paris, one part of powdered mica and enough glue or shellac to make a thick paste. When this filler is applied it will dry quickly and assume about the same degree of hardness as the mica segments. Another filler can be made up of powdered chalk or plaster of paris and shellac, and still another of water glass and powdered glass. The choice between these fillers largely depends upon the availability of the materials, since one works about as well as another. These fillers should only be used for small holes. When the segment is deeply burned the only successful remedy is to remove the bad segment and insert a new one.

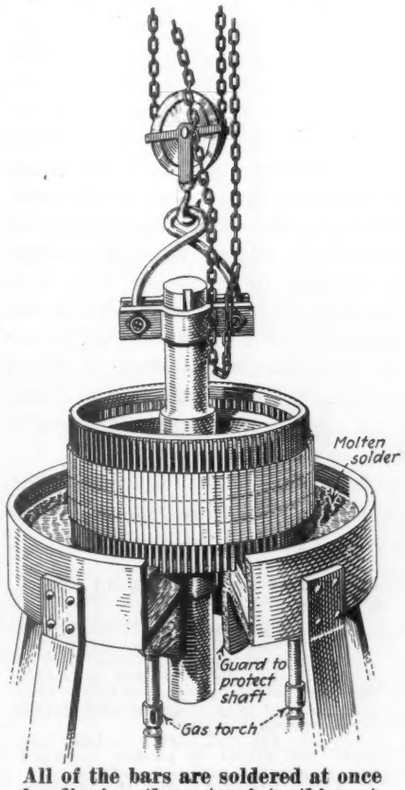
HENRY HAZLETON.

St. Louis, Mo.

A Special Pot for Soldering Induction-Motor Rotors

THE soldering of induction-motor rotors requires special attention which is sometimes neglected by repairmen. Poor soldering leaves very high-resistance connections which become excessively hot when the motor is carrying its load. Also if the soldering is not properly done, there is a likelihood that the rotor will be out of balance and thus set up excessive vibrations.

The soldering pot shown in the drawing overcomes these difficulties. After the solder is heated to the correct temperature the ends of the rotor bars are dipped into the molten metal, the rotor being hung over the pot with chain blocks. Care must be taken to have the end rings and bars well cleaned before attempting to solder. For cleaning them, a wire brush is very handy. A good soldering flux to use is rosin dissolved to



All of the bars are soldered at once by dipping the rotor into this pot.

a paste in alcohol. Care must also be taken to see that the surface of the solder is skimmed clean of all dross and dirt just before the rotor bars are dipped. With this arrangement it is possible for one man to solder four 25-hp. to 50-hp motors in an hour.

R. H. N. LOCKYER.
Bonnington Falls, B. C., Canada.

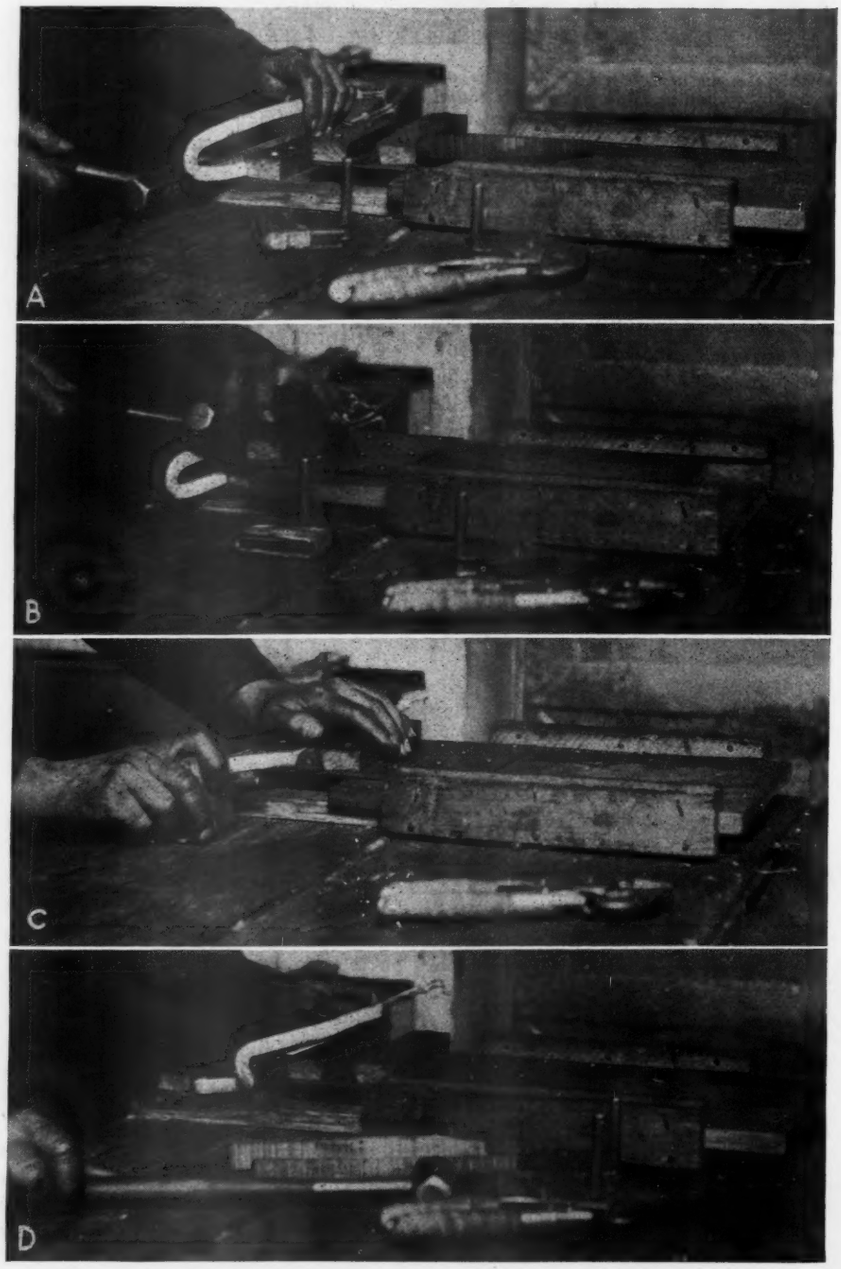
A Simple Device for Spreading Armature Coils

ALL coils used for rewinding the armatures of motors used in the plant of the Gary Screw and Bolt Co., Gary, Ind., are made and formed in the electrical department. After the coils are wound and taped they are spread to form in a spreading device which was made in the repair shop. As shown in the illustrations, this spreader consists essentially of a base, which is fastened to the work bench, and a slider which is somewhat shorter, but of the same width as the base and can be moved backward and forward on it. Guides fastened to the sides of the base keep the slider in place and both it and the base are provided with two cleats each, for holding the upper and lower legs of the coils.

The base may be made of a piece of hard wood about 2 ft. long, 8 to 10 in. wide and 1 in. thick, for ordinary-size coils, and is firmly screwed or nailed to the bench. The guides are made by nailing to the opposite sides of the base two pieces of wood approximately 1 ft. long and about 1/3 wider than the combined thickness of the base and slider. Two strips of wood are then nailed to the inner surface of these side pieces and serve to hold the slider down. The slider or movable unit consists of a 1-in. board about 18 ins. long working between the guides and carrying at one end a 3/16-in. steel plate to which are attached two wooden cross cleats. Two similar cleats are fastened to the forward end of the base.

For convenience in description these cleats, starting with the one on the base next to the operator in the illustration, may be numbered 1, 2, 3 and 4. Cleat 1 is mounted near the end of the baseboard with the edge at a slight angle (2 or 3 deg.) to the vertical from the edge of the baseboard. Cleat 2 is mounted with its edge at right angles to the baseboard and about 1 in. from cleat 1. This leaves a tapered space about 1 in. wide between cleats 1 and 2. Cleat 3 is mounted at right angles to the edge of the baseboard, and cleat 4 is mounted at a slight angle and about 1 in. from cleat 3. The taper on cleats 1 and 4 is made so that the wide ends of the two openings between the pairs of cleats are to the right side as the operator faces the spreader. The ends of cleats 2 and 3 should be rounded off at the points where the coil sides come in contact with them in order to prevent damaging the coil during the spreading operation. Where coils with different lengths of straight slot section are required to be spread in this device a set of Nos. 2 and 3 cleats is required for each length, the length of straight section being fixed by the length of these cleats. Two tapered wedges are required of such a thickness and taper as will hold the coil firmly between the cleats for the full length of its contact along the edges of cleats 2 and 3.

To spread a coil its lower leg is centered between cleats 1 and 2 and one of the tapered wedges is driven between cleat 1 and the coil. Then

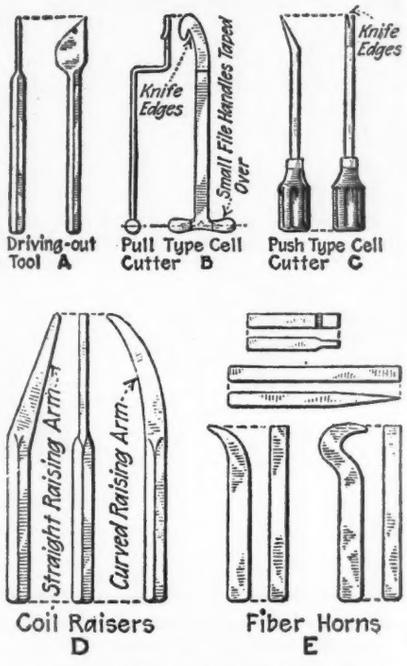


Four steps in spreading an armature coil.

A—The lower leg of the coil is placed between the cleats on the base and held by a tapered wedge.
B—With the slider pulled forward, the upper leg of the coil is also fastened between the cleats by means of a tapered wedge.
C—While the end clamp is held upright the slider is pushed forward and forms the coil.
D—After knocking out the wedges the formed coil is removed from the spreader.

the slider is brought forward with cleat 3 drawn through the coil and the upper leg is pushed down between cleats 3 and 4. The second wedge is driven between the upper leg of the coil and cleat 4 and the slider of the device is pushed back until the proper coil spread has been made. A stop should be nailed to the bench so that each coil is spread to the same width as the first one. When the spread is complete the wedges may be knocked out and the coil lifted free, complete and ready for dipping in varnish or shellac. In order to secure a uniform set of coil ends a pair of end clamps may be made similar to those shown in the illustration. These end clamps consist of two pieces of ⅛-in. iron with a rounded ear or extension at one end, bolted to a piece of wood about ½ in. thick. A ½-in. pin passes through a hole in the two ears. These clamps are slipped into place and the pin inserted before spreading, to give a uniform bend.

Gary Screw & Bolt Co., Gary, Ind. A. L. GEAR.



These simple tools are easily made and can be adapted to the armature repair work necessary in any shop.

Simple and Handy Tools for Repairing Armatures

FINDING it difficult to purchase just the kind of tools they desire, armature repairmen frequently have to make their own. Several of those that have been developed by the writer are illustrated here.

The driving-out tool, marked *A*, is used for driving coil leads out of the commutator bars to which they are soldered, either when stripping the armature or when removing the commutator. It is constructed of either hexagon or octagon tool steel and the blade is forged to the proper thickness. The edges of the blade are ground off on an emery wheel to the desired shape. A complete set of these chisels should consist of four, of the following dimensions: One with a ¼-in. shank and a 1/32-in. blade; one with a ¼-in. shank and a 1/16-in. blade; one with a ⅜-in. shank and a 3/32-in. blade; and one with a ⅜-in. shank and a ⅛-in. blade. This tool is only adaptable for use on commutators having solid risers, as those having flexible risers will not stand such rough treatment. Coil ends have to be removed from the flexible or more delicate risers by melting the solder.

The letters *B* and *C* in the diagram designate the pull type and push type of cell cutters, respectively. The pull-type cell cutter has a hook effect, with a cutting edge on the inside of the hook. This type is made of forged steel ⅛ in. thick and ½ in. wide. To allow free movement of the handle, the shank is raised about 2 in. higher than the blade.

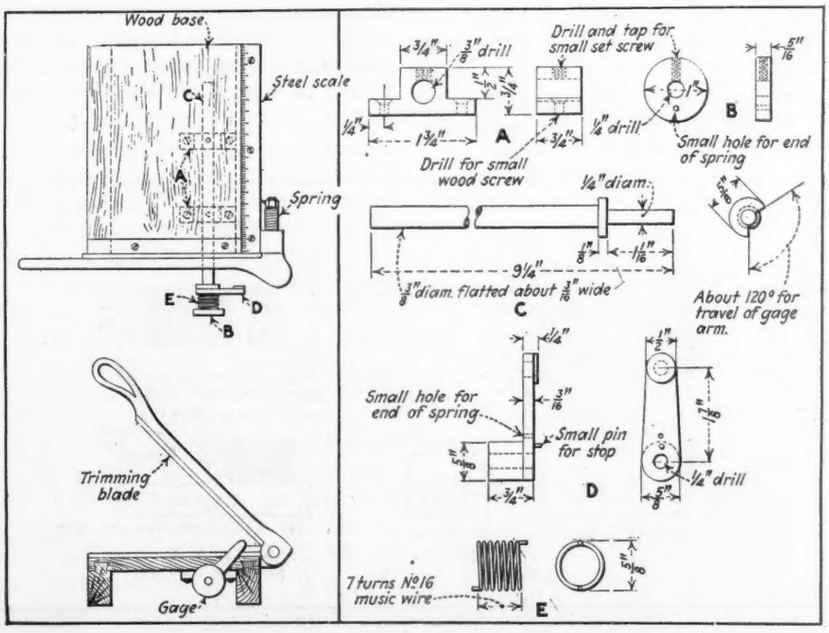
An old screwdriver forms the basis of the push-type cell cutter. It is first ground down to the proper shape, after which the beveled knife edges are filed out with a three-cornered file. The shank is then bent to about a 155-deg. angle at a point 1 in. from the end.

When testing a newly wound open-slot machine, either armature or stator, if one of the coils is grounded in the slot it is necessary to raise the grounded coil without damaging it in order to insulate the exposed parts. For this purpose the coil raiser or stripping piece *D* has been designed to take the place of a screwdriver. This tool is constructed of either ½-in. or ¾-in. hexagon or octagon steel. The service end is ground to the desired shape and the edges are ground off smooth.

For all kinds of close shaping work the fiber horns shown in *E* have been found to be valuable. They are useful for shaping the coil ends of armatures and stators. The corners of the horn should be well rounded off to prevent damaging either the coils or the worker's hands.

An Inexpensive Trimmer for Cutting Insulation in Strips

THE trimming or cutting of fish paper, pressboard, mica or flexible micanite is one of the jobs always on hand where motors are made or repaired. To do this with reasonable accuracy where the only tools are a straight-edge and a knife or a pair of shears, is a tedious task as anyone will agree who has had to mark out and cut up slot insulation with such tools. And yet the work



A photograph trimmer provided with a gage will cut strip insulation easily and accurately.

may be done very easily even though the shop cannot provide one of the large, standard insulation shears, for practically any establishment can afford to make up the trimmer herein described.

The basis of this trimmer is an ordinary wood-base photograph trimming board of a size suitable to the work to be handled. A board should be selected of the type having the blade-wear taken up by spring pressure as shown in the sketch. The wooden scale which is ordinarily part of the trimmer as purchased should be removed and an old steel scale fastened in its place, or one leg of a cheap metal square may be used. With these changes the trimmer is ready for work and it will cut cleanly and neatly all of the materials above mentioned.

Where many strips of uniform width are required, the use of a gage is advantageous. With the help of the machine shop the stop gage shown in the drawing can be easily produced. This gage has the special advantage that it can be used for very narrow strips as it is automatically depressed out of the way of the blade when the latter cuts, reappearing in proper position when the blade is lifted.

The various parts are all made of wrought iron or cold-rolled steel, and the dimensions given are for a gage used on an 8-in. trimmer. This gage might also be used on a larger trimmer without much change. The stop *D* is set to give the proper width of cut by means of the two set screws in the pillow blocks, *A* and *A*, which support the gage rod, *C*. The spring *E* returns the stop arm to its proper position after the blade is lifted if the work is so narrow as to cause the blade to strike the gage.

J. M. WALSH.

Gurney Elevator Company,
Honesdale, Pa.

Transformer for Testing Field Coils of Motors

FOR use in the repair shop of the Augusta-Aiken Railway & Electric Corporation, Augusta, Ga., the special transformer shown in Fig. 1 has been devised by the writer to test the field coils of motors. This device consists essentially of a rectangular core of laminated iron with one side removed, as shown in Fig. 1. On one end of this rectangular iron core a coil of 100 turns of No. 6 wire is placed and connected to a

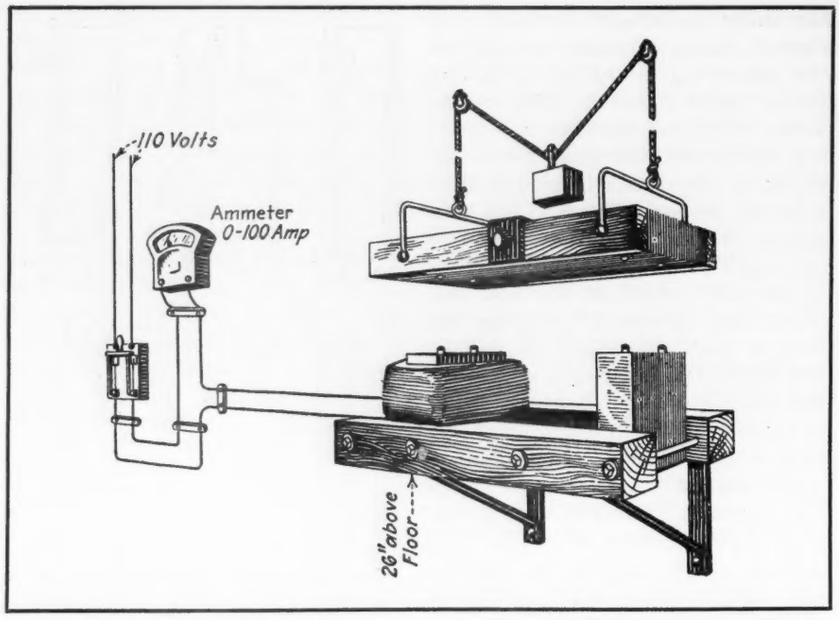


Fig. 1—The method of mounting the special testing transformer for determining defects in field coils.

110-volt circuit with an ammeter in series. When a field coil is inserted over the other end of the iron core—that is, the one shown at the right in Fig. 1—and the top side lowered into contact with the ends of the laminated core, the device is essentially a transformer with the permanent coil the primary and the field coil the secondary. When the field coil is free from grounds or short circuits it will act as an open secondary on a transformer, and no current except the exciting current, which is small, will be indicated on the ammeter. If there is a ground or short circuit in the field coil, it will act as a short-circuited secondary of the transformer and a current will flow in the primary or stationary coil of the device which will be indicated on the ammeter.

When applying the upper or movable side of the iron core it is essential that it be placed in immediate contact with the ends of the iron core, and dowel pins are provided for this purpose. In case there is an air gap between the side of the iron core and the ends, caused by not being placed in immediate contact, the reduced reactance of the primary coil will be sufficient to allow a considerable current to flow and thus give a reading on the ammeter which might be taken to indicate that the field coil being tested is short-circuited.

Details of construction of this special transformer and dimensions of the various parts are shown in Fig. 2. at the bottom of the page. The diagram for setting up the equipment is shown in Fig. 1 at the top of the column.

Augusta, Ga. A. E. KIRKLY.

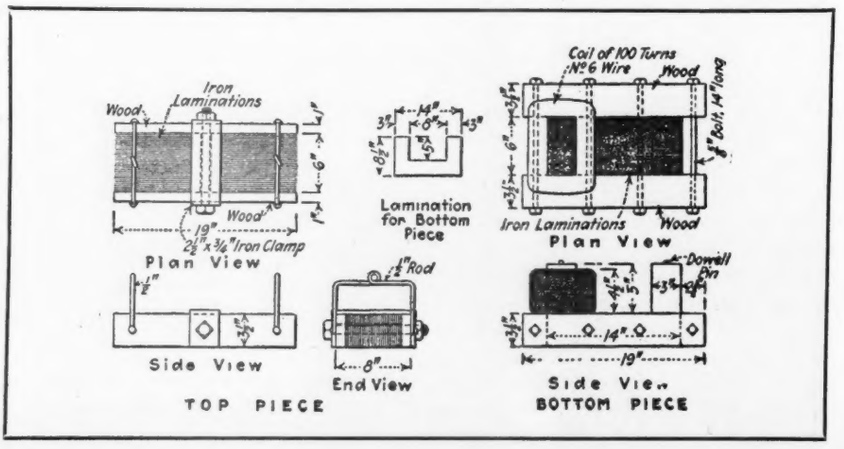


Fig. 2—Details and dimensions of the special field-coil-testing transformer described in this item.

A Simple Cell Bender for Forming Slot Insulation

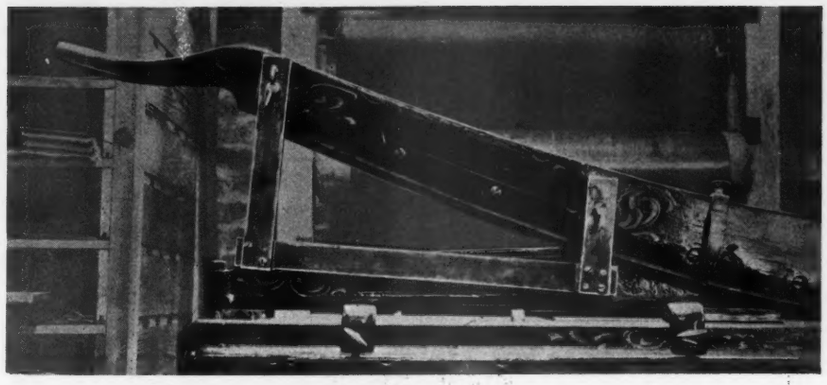
IN ORDER to bend insulating cells for the partially-closed slots of motors, the attachment shown in the accompanying illustration was made in the shop with which the writer is connected. It was attached to a 40-in. strawboard-cutting machine of the kind used in many repair shops. This fixture folds the cells and puts on a lip 1/32 in. wide, as shown in the drawing. The bender is made of ½-in. by 1½-in. cold-rolled steel. Two vertical bars hold a long bending bar to the cutting arm. The photograph shows the vertical bars attached to the cutter with two thumb screws. The knife holder has to be faced to receive the two vertical bars. The holes are drilled to receive the line-up studs.

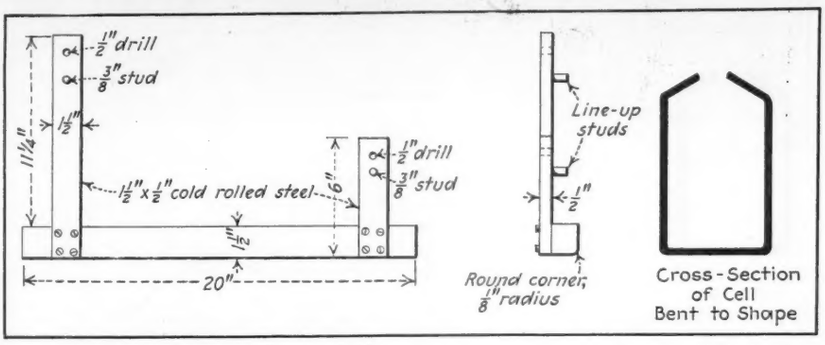
It will be noticed that one vertical bar is longer than the other, in order to give a long bending surface to press against the cell. The edge that goes against the stationary cutter is rounded off with ⅛-in. radius to prevent the insulation being cut. One bend is made at a time and then the strip of insulation is moved over to the position for the next bend.

This bender is not hard to make and is easily attached and operated.

A. C. ROE.

Detroit, Mich.





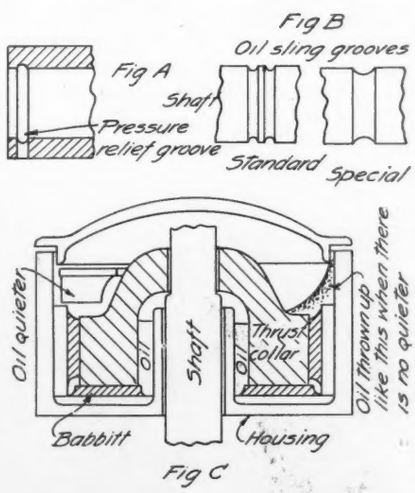
This device for bending slot-insulating cells to shape can be attached to a cutting machine.

Escape of Oil from the Bearings During Operation Prevented by Simple Methods

ONE of the troubles most frequently encountered is "oil slinging." This wastes oil and is annoying as well and may be remedied by allowing the oil which is under pressure in the film to squirt out sidewise along the shaft by providing a very small extra clearance or cutting a very shallow groove in the bearing. A pressure relief groove, Fig. *A*, around the box near the end with a drain hole at the bottom will catch oil squirted in this way and drop it back into the well. Usually there is such a groove only at the outer end of the box, but at times it will be advisable to put such a groove at the inner end also. Oil may be thrown by a high speed ring up against the oil lid and seep out around it. The remedy for this is a sheet metal cover under the lid to catch and stop the spattered oil, or else the use of heavier oil that will not throw so readily. It is well to see that the oil rings fit fairly snugly in the ring slot, otherwise oil may be thrown out at one side.

The oil sling groove on the shaft sometimes throws oil. A change in the shape of this groove may help. For example, a single deep groove such as is shown in Fig. *B* often serves better than two shallow grooves.

If oil splashes or foams too much it gets gummy. One way to keep a bearing from foaming is to add heavy oil in the proportion of about 1/3 of the amount of light oil ordinarily used. Bearings for gear-drive machines should fit fairly tight in the housings so that vibration will not rattle them loose. In vertical bearings, Fig. *C*, the oil sometimes whirls around so fast as to rise up the sides and come out at the cover joint; to stop this, a "quieter" which looks like a large washer with paddles sticking out on one side, is put in the top part of the housing.



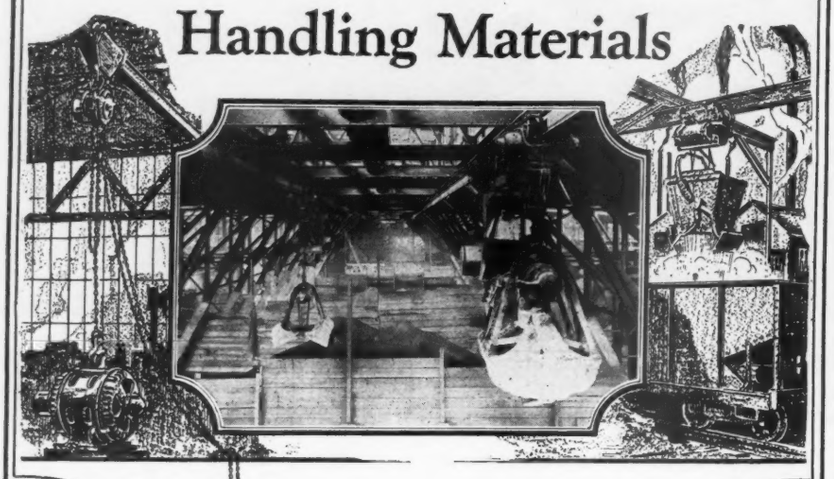
Simple remedies for oil troubles

Fig. *A* shows a small pressure relief groove which allows the oil to drop back into the well. A single deep groove, as in Fig. *B*, can sometimes be used to advantage in place of two shallow grooves. Fig. *C* shows how a quieter stops oil splashing.

It is well to bear in mind that: (1) covers on vertical bearings should not fit air tight; (2) bearing troubles are usually accompanied by heating; (3) a bearing temperature anywhere up to 75 or 80 deg. Centigrade is safe; (4) brass or bronze boxes take a longer time to wear to perfect condition than when babbitt is used.

A hot box may be due to one or more of the following conditions: (1) rough bearing surface, no oil film; (2) poorly fitted boxes or housings; (3) insufficient clearance; (4) too much clearance; (5) bent shaft; (6) poor or dirty oil; (7) no oil or not enough oil; (8) excessive belt pull; (9) end thrust by improper leveling; (10) end thrust by magnetic pull, improper centering; (11) oil does not circulate; it may be too thick or frozen; (12) oil rings bent or stuck and, (13) improper oil-distributing grooves.

Handling Materials



Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

How a Loader and a Portable Conveyor Save Half the Cost of Handling Sand

SINCE installing a loader and a belt conveyor the Crume Brick Company, Dayton, Ohio, has never had to shut down its plant for lack of material, although such shortages formerly caused expensive tie-ups. These machines are displacing six men and saving $3,902.14 a year in wages alone. The operation cost per ton is only $0.0732, which represents a 54 per cent reduction over the former cost. The machines have also reduced labor troubles which were unusually serious because of the disagreeable nature of the work they have taken over.

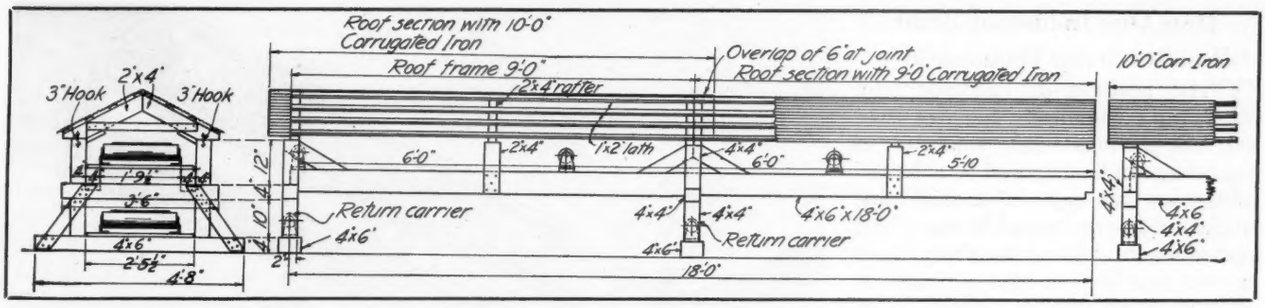
This company manufactures sand-lime brick and roofing tile. About three years ago it installed the Barber-Greene loader and an 18-in. by 30 ft. portable belt conveyor, shown in the accompanying illustration, to feed the long, adjustable belt conveyor which carries sand and gravel from the sand banks into the plant. First the material is dug out of the bank by the loader and discharged onto the short, portable conveyor. This discharges onto the long stationary conveyor, which carries the load into the plant and dumps directly into the 125-ton storage bin. The inclined stationary conveyor which elevates the sand into the storage bin is about 150 ft. long. At the foot of this stationary conveyor is placed a semi-stationary conveyor which is set approximately parallel to the face of the sand bank. This semi-stationary conveyor is built in twelve foot, interchangeable sections, each section covered with an "A" shaped corrugated Armco iron roof, as may be seen in the foreground of the illustration. This semi-stationary conveyor can be extended or shortened by adding to or taking away the required number of sections; the belt, of course, is shortened or lengthened, as necessary. How the sections are constructed and joined together is shown in the sketch on the next page.

The loader operates in connection with the 30-ft. portable conveyor and moves up or down the bank, cutting back the face of the bank parallel with the conveyor. When the material in reach of these two combined machines is about exhausted, the semi-stationary conveyor is moved fan-shaped with the lower end of the stationary inclined conveyor, previously mentioned, as a pivot. In this way the digging equipment is always kept within a short distance of the conveying system. The portable belt conveyor permits the operation of the loader over a considerable area before it becomes necessary to alter the length of the stationary conveyor. The outfit normally handles 150 tons a day, which it can easily do in three or four hours.

Hoppers for guiding the sand or gravel onto the conveyor belt are placed over the semi-stationary conveyor at any of the sections by removing the roof on the section and substituting the hopper. The base timbers of the section are of cypress in order to resist the weather.

As the face of the sand bank is quite high, at points being about 150 ft. above the level of the conveyor, it has been necessary to change the semi-stationary conveyor only two or three times, but as this as a comparatively simple matter, this same design could be used on banks that are not so high. This semi-stationary conveyor is driven by a separate motor so that its angle in relation to the stationary inclined conveyor is immaterial and it is very easily kept in alignment. The fact that the original stitched canvas belt has been in continuous operation since September, 1917, will readily prove this.

Formerly it required six men with wheelbarrows to do this work.
With these two portable machines two men can now keep a supply of sand on hand with three or four hours' work. The loader digs the sand from the bank and puts it on the short portable conveyor which in turn dumps it on a long stationary conveyor which carries it to the storage bins.



How the eighteen-foot, interchangeable sections of the semi-portable conveyor are constructed.

The roof is in two divisions, with the corrugated iron of one section overlapping the other. Sand is fed in at any point by removing a roof section and placing a hopper in position as shown in the accompanying photograph. Stephen-Adamson 20 by 4 in. return rolls are used to carry the belt. A somewhat similar conveyor may be used for the reclamation of coal.

The cost of operating these machines is very reasonable. A conservative estimate of their life is ten years. Repairs and maintenance have been low; an estimated allowance for repairs of $100 a year on the loader and $50 on the conveyor are ample. After three years' operation, the loader is still using the original buckets and discs.

An operator and a helper easily handle the two machines, and have enough time to look after the stationary conveyor. The loader naturally has to be moved frequently to keep it digging in to capacity. The portable conveyor also needs occasional shifting. Detailed costs of operation of the loader and portable conveyor are given in the accompanying tabulation.

Cost of Operation of Loader

Depreciation=$2,203.00÷10 years life	$ 220.30
*Average interest at 7%= 11/10 × $2,203.00×.07/2	84.82
Repairs and maintenance, estimated	100.00
Power: 30 kw-hr. per day × 300 days × $0.0275 per kw-hr.	247.50
Labor: 1 operator @ $4.00 per day ×300 days=$1,200.00; 1 helper @ $4.00 per day ×300 days=$1,200.00	2,400.00
Total annual operating cost for loader	3,052.62
Cost per day=$3,052.62÷300 days	10.18
Tons handled per year=150 tons per day×300 days=45,000 tons,	
Cost per ton=$3,052.62÷45,000	0.0678

Cost of Operation of Portable Conveyor

Depreciation=$814.00÷10 years life	$ 81.40
*Average interest at 7%= 11/10 × $814.00×0.07/2	31.34
Repairs and maintenance, estimated	50.00
Power: 10 kw-hr. per day×300 days× $0.0275 per kw-hr.	82.50
Labor: (included in loader cost)	
Total annual operating cost for conveyor	$ 245.24
Cost per day=$245.24÷300 days	0.8175
Cost per ton=$245.25÷45,000 tons	0.0054

*Allowing for interest credited on depreciation fund.

These two portable units were installed because the management of the Crume Brick Company felt that the machines would be more satisfactory than the six men ordinarily required to take the material to the semi-stationary conveyor in wheelbarrows. The wages of six men would amount to $7,200 a year; so the portable machines are saving $3,902.14 a year, or $0.6868 per ton.

This saving, however, is of no greater importance than the insurance which the machines give against delays in production. Now the machines can be operated to capacity for a few hours and enough material gotten ahead to last for some time. Formerly, working all the time it was difficult to get enough material to keep the plant busy and shutdowns were frequent. The cost of these delays is hard to calculate in dollars and cents, but it was too large an item to be overlooked.

The loader and portable belt conveyor were installed by the Barber-Greene Company, Aurora, Ill.

Using a Combination of Lift Truck and Monorail to Handle Heavy Rolls of Wire

IN HANDLING materials heavy and bulky units give considerable trouble because of the space they occupy and the difficulty of providing suitable containers or grasping devices. For this reason rolls of woven-wire fence had always been moved singly on two-wheeled warehouse trucks at the plant of the Elliot and Reid Company, Richmond, Ind. This required a large number of men and much hand piling.

Now the rolls of wire are rolled from the last operation at the fence machine to a near-by skid or platform large enough to hold 24 rolls, or approximately 4,000 lbs. of wire, as shown in the accompanying illustration. These platforms are lifted by a monorail hoist and piled three deep as shown. The bottom platform is set up on supporting legs high enough for a Steubing lift truck to slip under. The truck is then elevated by working the handle until the platform and its load are free from the supports. It can then be pulled to the warehouse or directly to the freight cars. If the storing in the warehouse is but temporary, the load is deposited on supports and the lift truck withdrawn. The load on this truck as shown totals 11,800 lbs., or almost 6 tons. Two men elevate the load easily through the multi-lift mechanism and with a third man move the load over the cement floor with very little difficulty after it is once started. This lift truck is 60 in. wide by 72 in. long and is made by the Steubing Truck Company, Cincinnati, Ohio.

Three men can handle this six-ton load of seventy-two rolls of wire.

Formerly the rolls of fence wire were handled one at a time. Now they are placed on this platform at the machines when finished. A monorail hoist lifts the platforms and tiers them three deep on a lift truck which carries them to the car or the warehouse. Each platform will hold 24 rolls; here the top platform is not filled completely.

How One Industrial Plant Handles Scrap Economically

THE problem of handling iron scrap economically and still keeping the various kinds separate so that they can be disposed of to better advantage has received considerable attention in one large Chicago plant manufacturing heavy forgings. Here a steel tote box on legs is placed at each machine and the borings, turnings, punchings or sheared ends drop directly into the tote box. The legs on these tote boxes are of such a height as to permit an Elwell-Parker power-driven, elevating platform truck to slip under, lift the tote box and carry it to the scrap storage, a distance of over 600 ft. from the farthest part of the plant.

These special tote boxes are placed alongside the outside waste storage bins. When the loads of waste are all out they are dumped into their proper bin by a Pawling and Harnischfeger monorail hoist on a transfer bridge. The hoist is shown lifting one of these tote boxes in the accompanying illustration. The steel tote box weighs about 700 lbs. and holds, depending on the type of scrap in it, about 5,000 lbs., making a total load of approximately three tons handled at a time. These tote boxes are made of ¼-in. steel and have an axle riveted to each side which is caught by the hooks on the special lifting hooks, as shown. This axle is slightly off center so that it will tip as soon as the balancing arm, shown in the illustration, is tripped. The front of the tote box is on a slope to form a lip and empty more easily. After emptying, the tote boxes are taken back to the shop.

Some of the bins are open while those for turnings and borings are roofed over so that they will not be exposed to the weather. These roofs, however, may be easily removed so that the contents of the bins may be loaded into a car with the monorail on the transfer bridge and a 36-in. magnet with a rated capacity of 600 lbs., although its actual lift depends upon the material; for example, about 1,200 lbs. of borings may be lifted at a time. The magnet and hoist operate on 220-volt direct current which is supplied by a special converter.

This scrap was formerly loaded into cars by men with wheelbarrows and required, depending upon the material, approximately a day and a half for four men to load a car.

Part of an industrial transportation system which reduced a sixty-men gang to twelve men.
The handling of borings, turnings, punchings and sheared ends illustrated here is only a small part of the total handling of materials in this plant. Another big saving through mechanical handling which is worth considering lies in the reducton of accidents.

Now one man with the monorail hoist and the magnet can load a car in half a day.

The Elwell-Parker electric truck and the Pawling and Harnischfeger monorail hoist are used for this work only a small portion of the day; the remainder of the time is put in on other work about the plant. The monorail hoist is used to unload steel —a large amount of steel rails is used—and through a system of overhead I-beam trackage distributes it around to yard storage. When this monorail hoist is not in use it is run into a housing built over a part of the I-beam trackage where it is protected from the weather.

The plant was originally laid out for doing all transportation by industrial railways with the trucks pushed by hand. Now gasoline tractors are used to pull the heavy loads on the industrial trackage. Lighter loads of small materials are carried on the electric storage battery trucks. Before these tractors and storage battery trucks could be used, some additional cement runways had to be placed along the industrial trackage. Plank roadways are used out to the waste storage as shown here. The industrial trackage, however, is still in place so that it may be used at any time with cars and tractors for withdrawing steel from the adjoining yard storage or other heavy work.

Through the entire rearrangement of the method of handling materials the yard gang was reduced from sixty to twelve men. In addition accidents were reduced because of the reduced hazard through mechanical handling of heavy rails and other steel parts.

The Elwell-Parker Electric Company, Cleveland, Ohio, built the elevating platform industrial trucks used in this installation. The transfer bridge and overhead yard trackage was installed by the Toledo Bridge and Crane Company, Toledo, Ohio. The monorail hoist was made and installed by Pawling and Harnischfeger Company, Milwaukee, Wis.

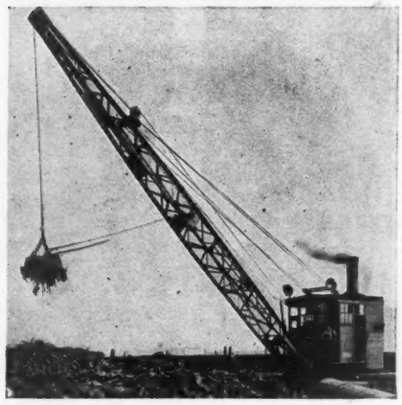
Magnet and Locomotive Crane Handles Scrap Iron Quickly at Low Cost

HANDLING scrap iron is one of the common labor jobs which can be done mechanically at a big saving in labor cost. With mechanical handling it is not necessary to round up a gang of men even though there is only a car or two to be handled, also the gang is not held idle if a few hours elapse between carloads. One scrap iron company uses the Link-Belt locomotive crane and Cutler-Hammer electromagnet shown in the accompanying illustration for this work and eliminates these extra gangs. This equipment can load or unload, in two hours, a car of 40 to 50 tons of scrap which would take a gang of eight men all day. In addition the magnet is used to tear down and spread out the pile of scrap to facilitate sorting.

The locomotive crane, made by the Link-Belt Company, Chicago, Ill., not only hoists and rotates, but also travels along the standard gage railroad track. It is provided with a standard draw-bar at each end for coupling up and moving cars about the yard. The 50-ft. boom can lift 3½ tons at the maximum radius, 50 ft., or 20 tons at 12 ft., the minimum radius, and proportionate loads at intermediate radii. For handling large pieces the magnet is detached and hooks or chains are used instead.

The magnet is 42 in. in diameter, of rugged construction, developed especially for this work by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis., and lifts from 500 to 1,500 lbs. of scrap at a "bite," depending upon how tightly the scrap is wedged into the car.

Sometimes a car with strips or rods of steel or lengths of cable which tangle up from the jolting of the car in transit make it difficult to unload. If badly tangled, the magnet is disconnected and a hook attached. This tears the steel apart so that it can be handled. It takes only a moment to change from hook to magnet or back again.



Doing a day's work for eight men in two hours.

Ordinarily it would take eight men all day to load or unload an 80,000 to 100,000-lb. car of scrap iron, but a locomotive crane and a magnet can do it in two hours. The magnet is also used to scatter the pile for sorting. The magnet is weather-proof.

Direct current at 220 volts is supplied to operate the magnet by a motor-generator set which receives its current from the 220-volt, a. c. Commonwealth Edison distribution system.

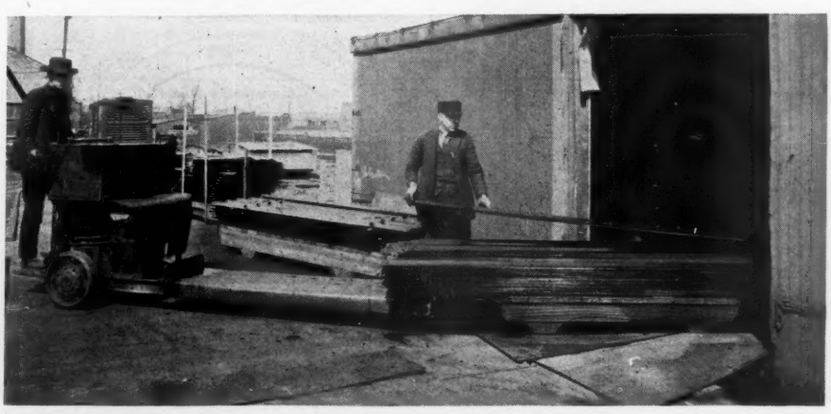
Handling Fifteen-Foot Steel on a Special Lift Truck

ORDINARILY, elevating platform trucks cannot be used for handling material more than eight or nine feet long, as the standard truck platform is only about 4½ ft. in length and the load will tip if it overhangs too far. To get around this difficulty, plants handling material ten to fifteen feet long use industrial lift trucks with an extra long platform, as is shown in the accompanying illustration. This special Automatic truck is used at the Robertson Brothers Manufacturing Company's plant in Chicago, Ill., fabricators of sheet-metal products. The platform on this truck is about two feet longer than the standard truck and will handle material ten to fifteen feet long. For this material long skids are used, although if the steel is not too light and flexible so that it bends easily, short skids may be used, as is shown in this illustration. One of the longer skids and its load are shown in the background.

The steel is fabricated in the building shown in the distance, piled on the skids as finished and then taken to the painting department, painted and piled back on the skids. These skids are carried by this elevating platform truck up a long incline to the loading platform, a distance of approximately 400 ft., and set to one side to drip. The truck then takes the loaded skid which has been standing the longest and runs it up to the car door as shown. One man counts the steel strips as he pushes them into the car, while two men pile them back into the car. At no time is the truck held up except to pick up, carry and deposit its skid. It makes no long waits while loading. When loading back in the ends of the car the truck takes the skid load inside and so eliminates all walking when unloading.

The power driven truck is used only for yard work and long hauls. The skids are moved short distances in the shop by an extra-long platform Jacklift, hand-operated, elevating truck made by the Lewis-Shepard Company, Boston, Mass.

Before this Automatic storage battery truck made by the Automatic Transportation Company, Buffalo, N. Y., was installed for this work, fifteen or twenty extra men were required to handle the incoming steel and outgoing production on hand trucks. Not only are fabricated parts handled on this truck, but it also moves all incoming steel to storage and from storage to the shop.



With an extra long platform on this elevating truck, long pieces may be handled easily.

After taking the loaded skid to the car door the truck goes about other yard hauling until the men are ready for another load. One man pushes the steel pieces off the skid to two men who pile them back into the car. Pieces ten to fifteen feet long can be handled with this special truck where ordinary trucks are limited to pieces eight or nine feet long.

Winding Split-Phase Motors

(Continued from page 235)

and 7, making clockwise windings in all cases. Likewise coils *B*, *C* and *D* are all wound in the same direction. The dotted lines indicate the way the leads are connected together to get the right polarity. It is possible to eliminate some of the soldered joints between coils of a hand winding by winding alternate coils in the opposite direction and not cutting the wire between coils, as shown in *C*, Fig. 11. Coil *A* in *C* of Fig. 11 is wound in the same direction as coil *A* in *A* of Fig. 11, but the wire is not cut at the finish of the coil in *C*, Fig. 11. It is brought around to slot No. 11 of coil *B*, then across the back of the stator to slot 9 and successively through slots 12, 8, 13 and 7. This coil *B* is wound counter clockwise as indicated by the small circles with arrows. Coil *C* is wound in the same direction as coil *A* and likewise coil *D* is wound the same as coil *B*. This method of winding saves cutting the wire and soldering, and does not require checking and grouping of coils later on.

Connecting a Skein-Wound or Hand-Wound Stator

After a winding is in place on the stator, the next job is to connect it up. An easy way to tell which leads connect together is to use what is called the "in-and-out" rule. When one has learned to apply this rule it will not be necessary to use a compass test for polarity. Fig. 11, diagrams *A* and *B*, will help to explain this method, which applies to both the running and starting windings

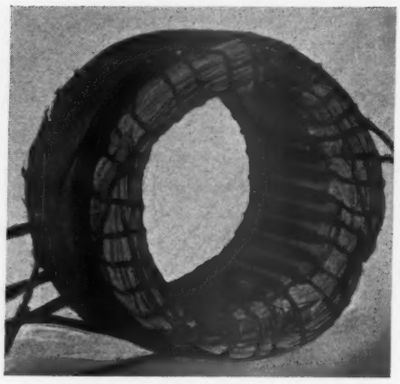


Fig. 13—How the coils are bound together with cord after they are wound in place.

This is a ⅛-hp., four-pole, 60-cycle, 110-volt motor. The running coils are hand-wound, while the starting coils are skein-wound.

of either hand-wound or skein-wound stators. First, take the running coils and bring out the leads as shown in diagrams *A* or *B*, Fig. 11. The starting and finishing leads of each coil should be brought out to the same side of the stator. The drawing *A* shows how the leads on a skein winding will appear. To make sure that the leads *"a"* and *"d"* belong to the same coils test them with a test lamp. Then take any convenient lead to start with and assume that the current is flowing into the coil through this lead as is assumed for the lead in slot No. 3 of *A*, Fig. 11. Then the current must flow out of this coil through the finishing lead in slot 7. Now the problem is to know which lead and which coil the lead in slot 7 should be connected to. If the current in slot 7 is *"out,"* then the current in slots 7, 8 and 9 must also be coming out as shown by the arrow. Then the starting lead of coil *B* is *"out,"* whereas an *"in"* lead is desired to take the current coming from coil *A*. The lead of coil *B* which is in slot 13 is an *"in"* lead and therefore the lead *"d"* of coil *A* in slot 7 is connected with the lead *"d"* of coil *B* in slot 13. Follow this "out-and-in" rule throughout and the connections will be correct.

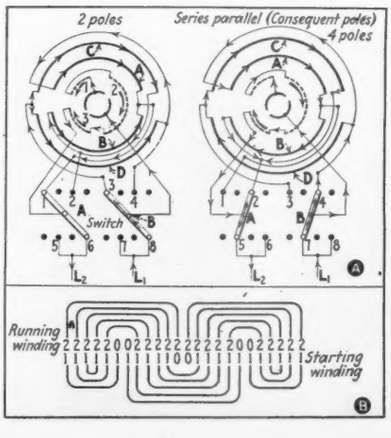
To state the rule briefly, connect an "out" lead to an "in" lead of the next adjacent coil. Or it may be worded in this fashion: Connect a starting lead to a starting lead and a finishing lead to a finishing lead. Then if a starting lead is picked out for the first lead of the entire winding the last lead will also be a starting lead. The last lead will be a finishing lead if a finishing lead is picked out for the first lead. With a skein winding the leads to the left can be called the starting leads.

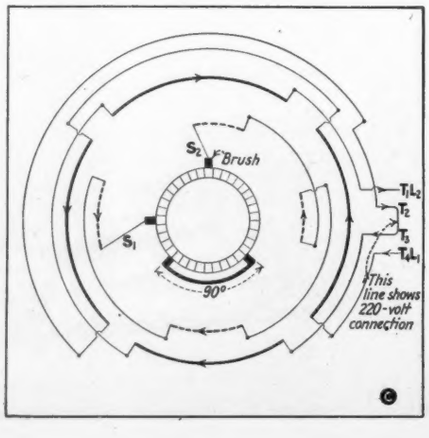
Direction of Rotation May Be Found Before Trying Motor

By using the above rule for connecting it is possible to have the motor run in any desired direction. If a starting coil is connected so that it has the same polarity as an adjacent running coil, the rotor will turn from the running coil toward the starting coil. The reason for this is that when connected to the line the current in the running coil is at a maximum a short time before the current in the starting coil is at a maximum. This means that the shifting or revolving magnetic pole produced by a combination of the starting and running windings travels from the running winding to the starting winding of the same polarity. The rotor is dragged around in the direction in which this magnetism moves. To test the direction of rotation after the stator is connected, a small dummy rotor may be made up as shown in Fig. 8. Starting and running windings are connected to the line as they would be in starting conditions and this dummy rotor is held inside of the stator. It will revolve in the direction in which the motor would turn.

Fig. 14—A special two-speed winding and connections for a repulsion-type motor.

The two-speed winding shown in *A*, *B*, and *C* may be connected by means of the switch for either two poles or four poles. The drawing at *A* shows the position for two poles, which gives the higher speed. This diagram shows a parallel connection. The diagram *B* is also a parallel connection, but the polarity of alternate coils has been reversed, and this forms a four-pole consequent winding, which gives the lower speed. The starting connections remain the same in both cases. The relative position of the running and starting windings is shown in *C*. At *D* are shown the connections for a repulsion type motor. This is a General Electric motor, type R1 526-4, 110 to 220 volts, ½ hp., four-pole, single phase, 60 cycles, 1800 r.p.m. For 220 volts, connect T_2 and T_3 together, and connect T_1 and T_4 to the line. For 110 volts connect T_1 and T_2 to one line and connect T_3 and T_4 to the other line. The armature has a two-circuit wave winding.





If it is necessary to reverse the direction of rotation the starting leads should be interchanged.

Connecting Various Types of Single-Phase Motors

Figs. 11, 12 and 14 show the connections for various types of single-phase motors. In Fig. 12 are ordinary connection diagrams for motors of two, four, six and eight poles. These diagrams also indicate the different methods of connecting the starting winding. In all the diagrams the heavy full lines represent the main windings and the dotted lines the starting windings. The small split inner circles indicate the centrifugal switch which is in the circuit of the starting winding. The diagram *A* in Fig. 12 shows one starting coil connected on each side of the switch while *B* shows the two coils in series on one side of the switch, while a dummy lead is brought from the other side of the switch. For four-pole motors, the diagram shown at *F* in Fig. 12 is probably the best one to use.

The drawing in *D* of Fig. 11 shows how to connect a small hand-wound compensated repulsion-type motor (type R I, General Electric motor). Note that there is no connection between the compensating winding and the line.

The stator of a four-pole single-phase (Westinghouse, Type A. R.) repulsion-type motor is shown in Fig. 10. This is a coil-wound machine with a concentric winding of six coils in each group. The sixth coil in each group overlaps the sixth coil in the adjacent group. Six different sizes of coils are required, and four of each size. Each coil is threaded in, starting with the smallest coil, then the ends are taped from slot to slot. Four leads are brought out for series or parallel connections.

A consequent-pole motor having four coils and eight poles is shown in *B* and *D* of Fig. 11. The diagram shows how the coils are connected together to form the consequent poles and the winding data is given below. A special two-speed winding, which may be connected for either two poles or four poles is shown in Fig. 14, *A*, *B* and *C*. A motor of this kind is used on wood-turning and dental lathes, etc. The drawing *A* shows the connections and the switch position for the two poles which give the higher speed. The running winding is in two sections and eight leads are brought out. The starting winding consists of three coils as shown, one long coil and two short ones. The diagram *A* shows a parallel connection, while *B* is also a parallel connection, but the polarity of alternate coils has been reversed, thus forming a four-pole consequent winding which gives the lower speed. The starting connections remain the same in both cases. The relative position of the running and starting windings is shown in *C* of Fig. 14.

Testing the Motor After It Is Rewound

After a motor is rewound it should be inspected carefully and given a running test at normal voltage. For all rewound small motors used on household appliances the writer advises a ground test with 900 volts alternating current at 60 cycles. They should also be tested for short circuits and given a polarity test with a compass. The troubles most often encountered after rewinding are grounds due to cells tearing or wire being wound accidentally between a cell and the iron, cells shifting all to one side and short circuits between turns caused by too much pounding.

Protected Motor Service

(*Continued from page* 228)

In this installation the convenience and protection of the control system has been forcibly illustrated on two occasions. In one case, one of the main fuses of the 2-phase 4-wire system blew and left the motors running single phase. The switches of the individual motors were opened almost instantly by the "thermaload" relays and the motors stopped. The machine operators in the plant being more or less unfamiliar with electrical characteristics, tried a number of times to start the motors without first investigating the cause of the trouble, but each time the attempt was made the relays again operated and opened the switches until finally they became convinced that something was wrong. An investigation (*Continued on page* 262)

Synchronous Motor Troubles

(Continued from page 217)

SYMPTOM	TROUBLE	CAUSE	REMEDY
10 Motor issues a harsh buzzing sound which remains constant in volume.	*A* Short circuited coil or group.	Same as for symptom No. 8.	Same as for symptom No. 8.
	B Open circuit.	Same as for symptom No. 8 or due to a short circuit which would burn out the coil and cause an open circuit.	Same as for symptom No. 8.
	C Grounds. One ground might cause a heavy current to flow in the grounded phase depending on what part of the winding the ground occurred in.	Dampness or same as for symptom No. 8.	Remove ground as soon as possible by lifting affected coil and reinsulating. One ground is not serious but is liable to cause others, and two grounds in the same motor is a short circuit.
	D Reversed coil or group.	Due to wrong connection during the making of repairs. A reversed coil or group will not prevent a motor from starting, coming up to speed or running.	Test with low-voltage direct current and a compass, and change the connections on the reversed coil or group.
11 Motor trips its circuit breaker and shuts down although the induction motors on the same system remain running.	*A* Surge on line.	*A* Momentary high voltage due to speeding up of alternator. *B* Lighting discharge during a storm.	No remedy. Voltage usually rights itself in a few seconds, when motor can be again started.
	B Low voltage.	Momentary slowing down of alternator.	Same as above.
	C Excitation ceases while motor is carrying a heavy mechanical load.	*A* Open circuit between exciter and motor field.	If exciter voltmeter gives a reading the trouble is either in the motor field, in the motor field rheostat or in the wiring connecting the exciter and motor field.
		B Exciter not operating.	If exciter voltmeter does not give a reading the trouble is in the exciter. Examine the brushes, field coils, armature and exciter field rheostat.
12 Motor issues a loud growling sound easily distinguished from those mentioned above and motor acts as if overloaded although direct-current meters show no over-excitation.	Rotor out of stator magnetic center.	*A* Motor not level.	Level motor bed plate.
		B Shaft collars shift 1. Too great end play of shaft.	Adjust collars for proper end play (the cores of synchronous motors are narrow in comparison with induction motors).

When Welding Iron and Steel

(*Continued from page* 226)

portion of the first layer. If the joint must be steam, water or air tight, it may be necessary to caulk the weld to close the imperfections, or in the case of vessels of very thin sections, compounds are sometimes used to fill these flaws.

Since cast iron is so brittle that it will break before it will elongate (stretch), it is necessary to consider the expansion and contraction effects. When the metallic arc is used, in addition to employing a small electrode and low current value, welding should be done in sections, completely finishing each section before starting another.

In order to minimize the chances of failure between the fused-in metal and the cast iron, wrought iron studs are often screwed into the casting on both sides of the fracture. This provides a ductile metal through the hardened section. Generally, cast iron welds should be rather wide, in order to insure sufficient strength at the union between the added and the original metal.

Where it is found necessary to machine one side of the weld, often the welding is not extended entirely through the section, but on the side to be machined a dovetail groove is formed, into which is peened copper or some other soft metal for a slight depth, the remainder of the section being filled and joined by fused-in metal. The groove may also be filled by using a low melting point electrode material, such as copper, nickel and some grades of bronze. This practice is extensive in automobile plants, where pure nickel electrodes are used for correcting flaws in engine cylinders by laying down new metal.

When welds of this kind are made, preparatory to welding the casting is completely or partly preheated, depending upon whether or not the parts oppose free play, in order to prevent rapid cooling and breaking from contraction strains. As silicon assists the precipitation of the carbon and manganese opposes it, a special low manganese and high silicon filler rod is used. In addition to destroying impurities and oxides formed during welding, the use of a cleaning flux or a coated electrode is necessary.

Where the weld area must be composed of the same metal as the original part, *i. e.*, gray cast iron, the conditions for welding must be very similar to those used in making cast iron. The surfaces to be joined must be brought to a molten condition, and molten cast iron from a filler rod added to form a continuous casting of the same kind of metal. All precautions should be taken for slow, uniform cooling to allow precipitation of the carbon from a combined state, as it exists in the molten cast iron, to a graphitic state in the finished weld, in order that the latter may be soft and machinable without difficulty.

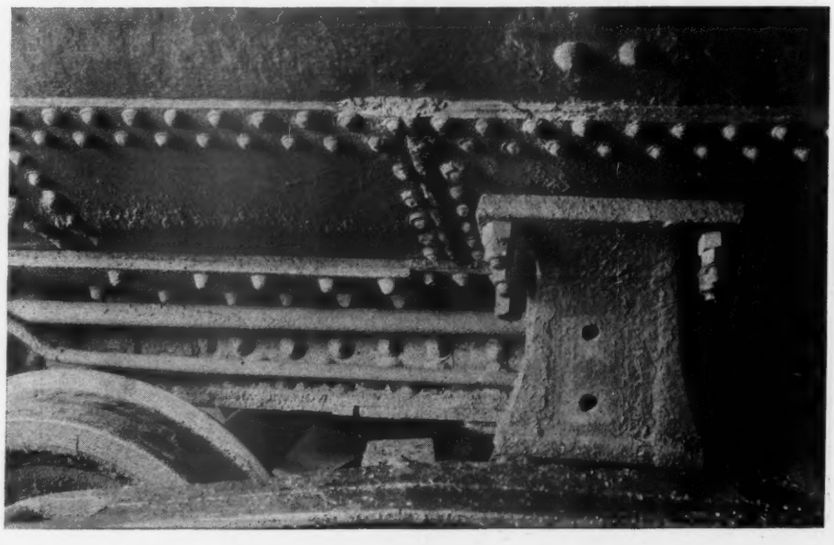
The casting should be maintained at or near a red heat during welding. This usually requires the part to be covered over with charcoal and the sides of the part protected by some form of refractory material as firebrick or asbestos. When the weld is completed the part should be allowed to cool very slowly, sometimes as much as twenty hours. This procedure allows the weld to be composed of metal as nearly equal to the original casting as is possible. Since, however, some of the elements of the part and of the added metal are destroyed by combustion and volatilization, the weld will be only approximately the same as that of the original part.

Some progress has recently been made in the welding of cast iron with the metallic arc process, using a coated cast iron electrode known as grade No. 11 and furnished by the Transportation Engineering Corporation, although preheating and slow cooling are necessary with this method, as with the oxy-acetylene process. The weld will be composed of cast iron of machinable quality. Further perfection of the welding of cast iron by this method is looked forward to with much interest, as the use of the arc process for this class of work will prove advantageous in many instances.

Welding Semi-Steel.—The same precautions and methods as those employed with cast iron should be taken in welding semi-steel. The amount of combined carbon is usually more in gray cast iron, while the amount of carbon as graphite is generally less. The effect of this difference from a welding standpoint is that semi-steel is more susceptible to the hardening produced by quick cooling from temperatures below fusion.

Welding White Cast Iron.—This metal cannot ordinarily be welded, due to strains produced by the localized heat of the welding process. An example of the effects of localized heating on such metal is found in the case of chilled car wheels, where pieces often shell out, due to localized heating caused by wheels sliding on account of brake application. While there may be some cases where the welding process could be applied for building up a worn surface of a chilled iron casting, owing to its extreme uncertainty, such welds should be limited to cases where failure would result in no serious damage to life or property.

Welding Malleable Iron.—In the outer portion, malleable castings offer but little more difficulty in welding than in the case of mild steel.



This illustration shows how a leaking seam in a Vanderbilt tank was closed by welding.

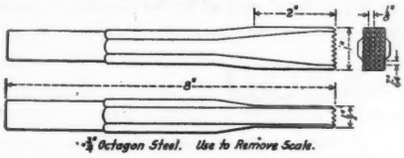
The heat value used should be sufficiently low to limit the depth of fusion to the softened section, which extends only for a slight depth, often not more than 1/16 in. Even then the deposit may be slightly hard, because in some castings the decarbonized section is so thin that the fusion unavoidably extends through into the core. Such castings should be annealed before machining.

When the welding extends into the core the difficulties encountered are practically the same as in welding cast iron, as the carbon in the core will cause the formation of a hard and brittle line. Therefore, the welding of malleable castings requires practically the same methods and procedure as employed in gray cast-iron welding, and wrought iron studs should be used to reinforce the union between the added and original metal.

Welding Wrought Iron.—In arc welding, wrought iron can usually be distinguished by the fluidity of the metal, caused possibly by the fluxing action of the slag which it contains. The slight tendency of the metal to run when welding in positions other than flat requires a little more effort on the part of the operator than in welding mild steel. There are practically no bad effects produced on the structure by the heat of the welding process.

Welding Cast Steel.—When of the ordinary composition and without special heat treatment, no unusual difficulties are encountered. With parts of considerable thickness the main body of the material absorbs the heat so fast that a quenching action results on the metal which is adjacent to the weld and is heated above the critical temperature. This part will, of course, be made hard if the carbon content is more than two-tenths of 1 per cent. The strains and stresses set up by the quenching action and hardened structure are severe and where the hardness is great they may cause failure in a short time, especially under vibratory stresses. For service of this nature the parts should be thoroughly annealed to remove the hardness and relieve strains produced by welding. When annealing is not practicable, medium or high-carbon steel parts should be preheated and welded while hot, to minimize the effects of the welding operation on the base metal.

Sections of medium carbon steel up to approximately 5/8 in. thickness are not susceptible to structural changes which cause hardness, because the metal heated above the critical temperature will not be cooled sufficiently quickly to produce a quenching action.



A roughing tool like this is useful for loosening scale.

It is made of ¾-in. octagon steel. The upper end may be turned off round to permit using the tool in an air hammer.

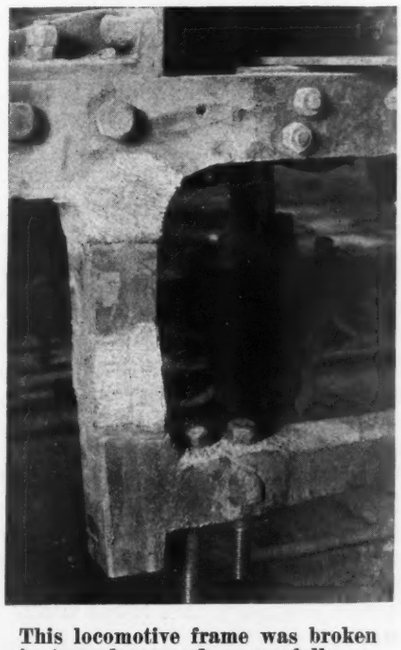
Welding of Steel Plates, Shapes and Forgings.—The problems met in the welding of steel which has had mechanical treatment are practically the same as those met in the welding of cast steel, so far as the effects of the heat are concerned. In the welding of such parts it must be remembered that the metal in the original part is physically superior, due to the mechanical treatment, while the weld is composed of metal in cast form. In forming joints between plates and shapes, this difference in physical character is partly or totally compensated for by increasing the area of the weld section over that of the part welded. Where this is done the tensile strength can in most cases be made equal or even superior to that of the original part, provided the weld is properly made. The structure of plates and shapes of the composition of light cast steel sections will not be seriously affected adjacent to the weld on parts up to at least 5/8 in. thickness.

Investigation of welds made on steel parts of considerable thickness such as piston rods, crank pins and axles, show that the steel adjacent to the fused-in metal is affected by the heat in the same manner as described in the case of cast steel welding, by the transformation of the physical structure from a normal to a hardened condition, due to sudden cooling of the metal heated above the critical temperature. Heavy parts which are subjected to vibratory stresses should therefore, when welded, be thoroughly annealed afterward.

For general repair work on wrought iron, plates and shapes, and steel castings the electric arc process is superior to any other welding process owing to its low cost and ease of application. The initial cost of the arc welding plant is considerably higher than that of the oxy-acetylene plant, but as a general proposition, where there is enough repair work to be done to require the operation of one oxy-acetylene flame three hours per day, the installation of the arc apparatus will show a substantial yearly saving considering installation cost. When it is considered what a large number of metal machine parts come under the above repair classification, the wide possibility of applying the process is obvious. This, of course, is neglecting the application in the manufacture of machine parts.

Arc welding offers many possibilities but unless much care is taken to see that it is intelligently used, disappointment and loss are liable to result. In particular, when parts which have within them possibilities of death and destruction are welded by any process, too many precautions cannot be taken to insure the highest quality of work.

[Acknowledgment is made that some of the illustrations used in this article were taken from the book, "Electric Arc Welding," by E. Wanamaker and H. R. Pennington, published by the Simmons-Boardman Publishing Company.—Editor.]



This locomotive frame was broken in two places and successfully repaired by arc welding.

A good deal of skill and care are required in welding these parts to make a weld which will withstand the severe service to which it is subjected and to avoid producing stresses or distortion by contraction. To compensate for the contraction of the added metal, the edges, prior to welding, should be forced apart 1/8 in. to 3/16 in., depending on the size of the frame, heat and method of welding. Also the free space between the frame points should be greater at the end toward which the welding progresses.

Management That Includes Bosses in the Office And in the Shop

Was the Viewpoint in Discussions of Industrial Plant Problems at the Meeting of the Society of Industrial Engineers in Detroit Last Month

By FRANK E. GOODING
Associate Editor, Electrical Review and Industrial Engineer

THE GENERAL topic under discussion at the eighth national convention of the Society of Industrial Engineers, held at the Hotel Statler, Detroit, Mich., April 26 to 28, was "The Influence of Industrial Engineering on the Earnings of Capital and Labor." Every session brought out practical viewpoints since all of the scheduled speakers were men engaged in actual production or the management of industrial plants. Another practical and profitable feature of the program, which is an established practice of the Society, was the devotion of forenoons to trips through Detroit's largest industrial works. The afternoons were devoted to short papers and round-table discussions, while the heavier papers and addresses were left for the evening meetings.

As this was the first meeting of the Society since the publication of the report of the Committee on Elimination of Waste in Industry, that report was naturally referred to frequently. One widely quoted sentence of the report served as the basis for much of the discussion. This sentence reads: "Over 50 per cent of the responsibility for these wastes can be placed at the door of management, less than 25 per cent at the door of labor, while the amount chargeable to outside contacts is least of all." In the committee's report, the term management included anyone in an organization who has the direction or supervision of men or operations, from the president down to the subforeman, or gang-boss.

In searching for some means to aid management to reduce its proportion of waste, the President of the Society, Joseph W. Roe, Head of the Department of Industrial Engineering, New York University, and formerly connected with the Pierce-Arrow Motor Car Co., took as the subject of his address, "The Measurement of Management." At present, practically the only measurement of management is profit. President Roe set up several criterions which will serve as a basis for further investigations which are to be carried on by a committee.

The Growth and Trend of Industrial Engineering

In his paper on "How Industrial Engineering Serves the Factory Manager," Karl Wennerlund, Industrial Engineer, General Motors Corporation, Detroit, spoke of the growth and trend of Industrial Engineering. Time and motion study for rate settings were the earliest development. This, however, quickly showed the need of another like development—that is, the development of machinery which would permit greater speed and better operation, better designed tools, heavier belting and machines, speeding up of shafting or individual drive, and an increase in bearing area. With higher speeds, and increased belt tension, together with the more complicated machinery, there came another problem—proper maintenance—which industrial engineers have found vitally interesting.

$2,700,000,000 Lost Annually Through Fatigue in Industry

"Unnecessary tiring of workers by uncomfortable benches or chairs, or no chairs at all, and other 'industrial scourges to spirit' costs American industry $2,700,000,000 annually, estimated on a basis of 20 cents a day for each of the 45,000,000 workers in the United States," according to Frank B. Gilbreth, chairman of the national committee for the elimination of fatigue in industry, who has made an extensive study of the subject. "The American workbench is like a coffin," he continued. "The man who makes it doesn't want it, the man who buys it doesn't use it, and the man who uses it hasn't a word to say about it. The trend of industry is getting away from this. We are now making laboratory tests of tables, chairs and footrests of adjustable heights, and ultimately industrial plants will fit working conditions to the individual and not compel the individual to fit himself to the working conditions."

The committee on elimination of fatigue is now recommending the painting white of every industrial toolroom in the United States.

"White paint is a little cheaper, but white walls have to be repainted," said Mr. Gilbreth. "Of course, black paint, some niggardly manufacturers say, doesn't show the dirt like white paint, but they can't kid themselves that black walls aren't dirty because they happen to be black. Look at the dark for a while and the pupil of your eye gets larger; look into the light and the pupil gets narrower, like an Indian's. Changing from one to the other is one of the quickest ways to tire the worker.

"Workers slow down, naturally, when tired. We spend one-third of our time in bed, one-third at work, one-third at play. Then why should we not have a first-class work place? Industry has thought too long that it was sufficient to give a worker a place to work and has given little consideration to making the place comfortable for the particular individual working there."

Gilbreth visited Prague last month upon the advice of the American minister of Czecho-Slovakia. The Masaryk Labor academy, Mr. Gilbreth reports, is at present conducting conferences where college professors, scientists and workers are siting about the same table trying to find the one best tool for each piece of work.

While discussing fatigue, Yoichi Uyeno, chief director of the Institute of Industrial Psychology, Tokio, stated that Japanese scientists had discovered that while fatigue increases in arithmetical progression, it recovers by geometrical progression. As a result, rest periods had

been introduced in some Japanese factories in both forenoon and afternoon for recovery from fatigue. In addition, gangs of men on similar work were chosen so that men of about the same natural speed were put together. By developing the instinct of rivalry, an increase in production of approximately 35 per cent has resulted.

Practical Discussions on the Conservation of Materials, Plant and Equipment and Labor

Friday afternoon was given over to fifteen-minute talks by workmen and by production managers on the conservation of materials, of plant and equipment, and of labor. In this, Anthony Fritz, Penberthy Injector Company, Detroit, Michigan, emphasized the need of the protection of the surface of materials to prevent corrosion and waste. He mentioned that the U. S. Bureau of Mines estimates that one million tons of metal are lost yearly through corrosion. Too much attention cannot be given to the preparation of metal when it is to receive any anti-corrosive protection covering. In contrast, Mr. Sawin, Federal Rubber Co., Cudahy, Wis., told how his organization attacks the conservation of material problem from an entirely different aspect, devoting the larger proportion of the attention to the supervision of manufacturing processes. A plan is in effect in this plant whereby each general foreman and assistant foreman receives, in addition to his salary, a bonus based on the following factors: (1) Percentage of seconds; (2) cost of repairs to products; (3) percentage of waste, (4) departmental unit cost of production; (5) amount of power used, and (6) direct overhead costs.

The direct result of this better supervision policy has been a saving of over $400,000 in the first year.

In discussing the conservation of plant and equipment, L. H. Low of the Ford Motor Company, emphasized that in his opinion the most important point lies in efficient plant layout and arrangement.

Next in importance to the layout, come the machines. The policy of the Ford Motor Company is interesting along this line. Quoting Mr. Low: "No machine is put on production before the superintendent of machine repairs has inspected the oiling system. Strangely enough, most machine tool manufacturers consider the oiling system of minor importance. We have received numerous machines equipped with small, spring-capped oilers which would not hold sufficient oil to keep the machine from running hot for ten minutes. Sight-feed oil cups of large capacity on small machines are most satisfactory. On large machines a central oil tank with individual lines running to each of the several parts, each line having a sight feed, such as the motorcycle feed, is the proper equipment. These oil systems often run into money but are well worth their cost. Do not make the mistake of putting one sight feed between the tank and header and none on the individual lines, as this will end in disaster to the machine. At the Ford Motor Company, the oiling of the machine is not left to the operator, but is taken care of by a man who does nothing else. However, the operator is also responsible for the machine and shuts down or notifies the oiler when he believes it necessary.

"Small repairs should be attended to immediately, for they prevent excessive wear. A department of some 60 men is maintained to repair small tools, such as Yankee screwdrivers, shears, boots, founder's shoes, etc. Last year we completed a conveyor which brings castings and forgings to the machine shop from the foundry and heat treat. This conveyor does away with 150 trucks which were much more costly to maintain than is the conveyor."

In discussing the same subject, Emil J. Schmidt, Sewell-Clapp Envelopes, Chicago, emphasized the necessity of attention to the details of maintenance and operation to get a smooth running organization. According to Mr. Schmidt: "A smooth running plant is no accident. Whenever we find a clean, orderly plant with little confusion, you can be sure there is good management behind it, and where we find such a condition we know that the manager is intelligent enough to make sure his equipment and plant are kept up.

Mr. Schmidt emphasized that maintenance standards should be set up based on a definite policy, which should include performance, maintenance expense, and also standards and supervisions. In organizing the maintenance work, the management should be sure that: (1) The responsibility is definitely fixed, (2) specialization of maintenance functions are clearly recognized, and, (3) adequate equipment is provided.

How Every Workman Helps to Sell the Product

A fitting conclusion to these meetings was the interesting talk by Norval A. Hawkins, Director of Sales-Advertising-Service, Advisory Staff, General Motors Corporation. Mr. Hawkins has some most interesting ideas as to who are the real and best salesmen of a product.

"I believe the best salesman we have is the workman who takes pride in his task and who builds that pride into our product. The salesmen who meet the public and get the orders are not nearly so important to the success of our business as the salesmen in overalls who really love their work of making our products good products. The best salesmanagers in the world cannot make a permanent success of marketing a product indifferently manufactured by employees who have no pride in their work."

Mr. Hawkins went further and emphasized the necessity of those who have charge of workers impressing those under them with the importance of opening their eyes and seeing beyond the machine, outside the factory to the customers who will use what they make. If they become interested in the people who will buy their product—the men who actually meet the payroll—they will do better work because they are performing an actual service for the user. A factory can operate only when sales are made, and the worker should be made to realize this as fully as the salesman, for without the sales the payroll must cease and the factory must stop—his job must end. Ordinarily, the salesman in his work says "we" when he refers to the company. The worker, on the other hand, says "they." When the worker feels that he is an actual part in the production and sales of the product, he, too, will say "we." When that happens, much of the industrial problem will disappear.

An exceedingly important part of this convention was the inspection trips which gave an opportunity to see how other organizations were meeting their problems of production and operation. Among the plants open for visitation were Ford Motor Co., Detroit Steel Castings Co., Cadillac Motor Car Co., Central Forge Co., Detroit Vapor Stove Co., Detroit Pressed Steel Co., Burroughs Adding Machine Co., and the Hudson Motor Car Co. The next meeting of the Society will be held in New York City in October.

Trade Literature
you should know about

Automatic Transportation Company, Buffalo, N. Y.—Numerous illustrations showing installations of electric storage battery trucks, tractors and engines are given in a booklet, "Efficient Interplant Transportation," issued by this company. These examples indicate the range of industries where this type of industrial transportation may be used and offer suggestions which may be useful in solving other material handling problems.

Cote Bros. Mfg. Corporation, Chicago, Ill.—A folder entitled "Simplicity Fuses" has just been issued describing the new refillable fuse of that name, whose outstanding characteristic is its simplicity of operation. This fuse consists of only two parts and the tiny refill cartridge. The salient features are consistent operation over a very long life.

Green Equipment Corporation, Monadnock Block, Chicago, Ill.—A recent booklet describes the Aurand commutator slotter. This is a hand-operated machine comprising a small universal motor driving a 1½-in. circular saw through a suitable gear reduction.

Sangamo Electric Company, Springfield, Ill.—A locomotive type ampere-hour meter for use on battery-driven trucks, mine locomotives and the like is described in Bulletin 58, superseding Bulletin 50. This meter indicates at all times the state of charge or discharge of a storage battery and automatically terminates the charge at the proper time.

Hutchinson Manufacturing Company, Norristown, Pa.—A folder describing a new woodworking machine is being distributed. This device is motor-driven and portable and is designed for performing 15 different woodworking operations.

J. D. Wallace & Company, Chicago, Ill.—A leaflet which is being distributed describes a portable band saw which has been developed by this company. This machine is 5 ft. 9 in. in height and occupies a floor space 15 by 29 inches. It is driven by a General Electric ½-hp. ball-bearing motor and can be operated from an electric light circuit.

Payne Dean Limited, 103 Park Avenue, New York City—Bulletin 43-A has recently been issued and describes the Dean valve position indicator, water level indicator, mechanical valve opening indicator and constant level control. These units of equipment are used with the Dean system of remote and automatic control of pumping stations and reservoirs.

Hot Flo Electric Company, 533 Seventh Avenue, New York City—Recent literature describes an instantaneous electric water heater for connection to a faucet. This heater is of particular value industrially where hot water in comparatively small quantities is wanted intermittently. This runs hot or cold water from the same faucet.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Descriptive literature is being distributed on a new type of manually-operated, non-automatic, single-throw gap switch for outdoor service, recently placed on the market.

The Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill.—A folder entitled "Janette Automatic Electric Air Compressors" describes the small portable and stationary units manufactured by this company. The type "E" compressor is a single cylinder outfit weighing 38 lb. The "EE" unit has two cylinders giving twice the capacity of the other. The "National" type comprises one of the foregoing mounted on an air storage tank provided with air reducing valve and gauges. The working parts of all of these units are inclosed, with noiseless gears running in oil. They are provided with an automatic switch which can be set as desired and are designed for operating blast lamps, air brushes, small furnaces and numerous other similar industrial services.

Black & Decker Manufacturing Company, Towson Heights, Baltimore, Md.—A miniature catalog covers various portable electric tools such as portable drills, screw drivers, socket wrenches and grinders.

Kales Stamping Company, 1659 West Lafayette Boulevard, Detroit, Mich.—A four-page leaflet gives a list of sizes of special washers in any gage and any material.

O. C. White Company, Worcester, Mass.—A recent catalog describes the many adjustable electric light fixtures manufactured by this company.

Pennsylvania Pump & Compressor Company, Easton, Pa.—Form 102, superseding 101, has recently been issued describing belt and steam-driven types of air compressors and vacuum pumps.

McGill Manufacturing Company, Valparaiso, Ind.—A circular describes the Levolier fixture switch. This is a very small unit designed for use on canopies, ceiling pans, wall brackets and other fixtures. It is furnished with a 2-in. chain, connector and 10-ft. cord with ball, and will take up to No. 14 wire from the top or sides.

Page Steel & Wire Company, Bridgeport, Conn.—Catalog No. 500 is a new handbook describing Page-Armco welding rods and electrodes of Armco ingot iron for oxy-acetylene and electric welding. In addition, numerous tables and other data, including specifications for electrodes of the American Welding Society, make this a useful handbook for industrial men interested in welding.

The Merrill Company, Ipswich, Mass.—A leaflet is being distributed describing and illustrating "Merrico" outlets.

Cowan Truck Company, 7 Water Street, Holyoke, Mass.—The Cowan steel-frame, lift-truck skid is described in a recent bulletin. This skid is made of yellow-pine planks riveted and bolted to a steel frame with malleable iron legs.

Protected Motor Service

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then revealed the blown fuse. The second case occurred when one of the gears of a rolling machine broke and the machine jammed. The overload caused the relay to operate, open the switch and stop the motor. The operator, not knowing of the trouble, tried several times to start the machine, each time without success, until finally it was brought to his attention that the reason for the failure of the motor to start was because of the broken and jammed machinery. In both these cases were it not for the protection afforded, the motors might have been seriously damaged before the real cause of the trouble was discovered.

The replacement of steam drive by this electrical installation has not only improved conditions of the plant as a whole, eliminated noise, dirt and confusion, but it has also increased the production capacity. Heretofore the capacity was thirty-five tons of springs per month—it is now more than forty-two tons per month. The individual springs for pleasure cars weigh from 17 lb. to 70 lb. and for trucks from 40 lb. to 320 lb. In addition to the increased production capacity, there has been a considerable saving in time, labor, materials for repairs, etc. The economy of the change is evidenced in many other ways. Departments are now independent, work can be performed outside of regular business hours without increased cost, and it is no longer necessary to start up the entire plant when a small rush repair job is ordered.